USER GUIDE FOR HRIR MODIFICATIONS TO THE APTS GROUND STATIONS

Contract No. NAS5-667

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Greenbelt, Maryland

AED-M2059

Issued: November 23, 1965

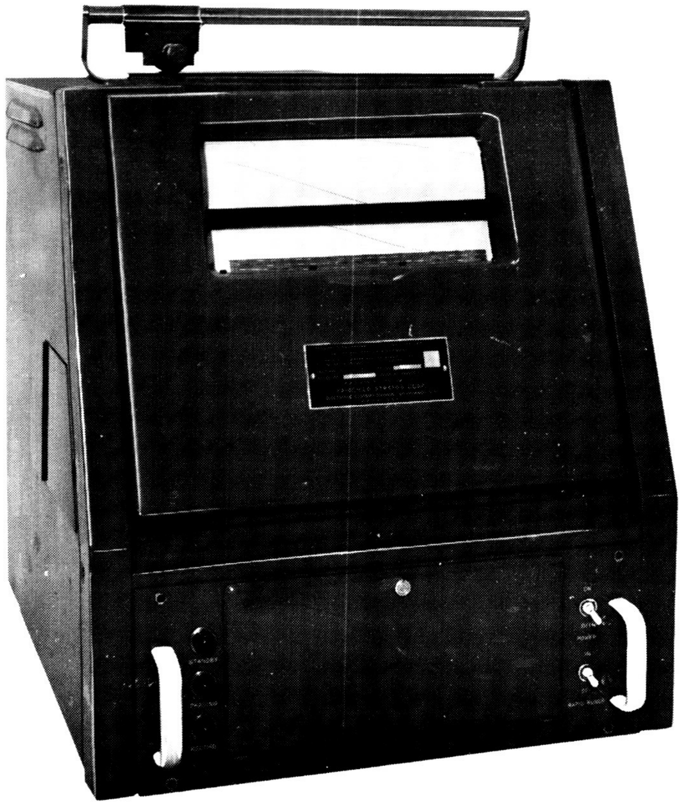
TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

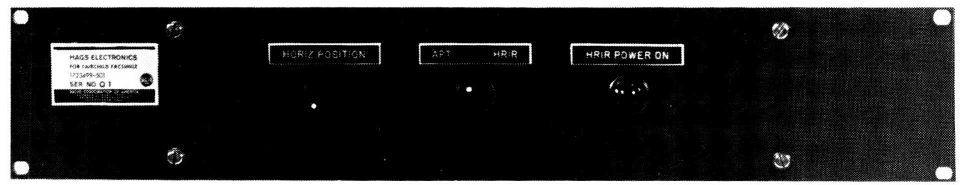
LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

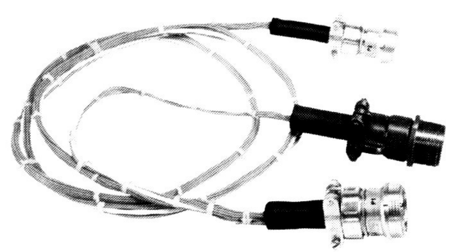
LIST OF TABLES



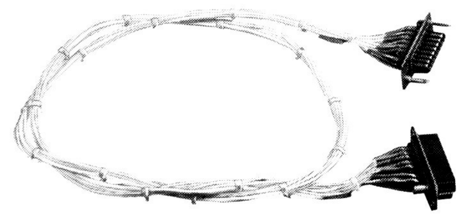
Facsimile Recorder



HRIR Converter



Interconnection
Cable



Extender Cable

Frontispiece Facsimile Recorder, HRIR Converter and Cables

SECTION I

INTRODUCTION

A. SCOPE

This document describes the modifications required to convert APTS Ground Stations for the processing of High Resolution Infrared (HRIR) signals. Specific details presented in this document pertain to APTS Ground Stations that use the Fairchild Facsimile Recorder. The modifications to the equipment, although applicable in theory for other radiometer rates, are specifically detailed for the Nimbus C radiometer rate (44.715... rpm). For future Nimbus satellites the radiometer rates will be different and require revisions to the modified equipment detailed in this document. The modifications were designed by the Astro-Electronics Division (AED) of the Radio Corporation of America for the National Aeronautics and Space Administration (NASA) under Contract No. NAS5-667, Modification 86.

B. PURPOSE

The purpose of this document is to provide the HRIR system philosophy and technical data required to understand, fabricate, and install the equipment required to modify the ground station for HRIR data processing. System philosophy, presented in Section II, contains background information on design parameters and information required to interpret the facsimile printouts. Technical data, presented in Section III, is described for both "manual" and "automatic" modes of operation. The manual mode of operation will require modifications of the Fairchild Facsimile Recorder shown on the frontispiece and represents the absolute-minimum conversion effort required for reception and processing of the HRIR data. For the automatic mode of operation, the Fairchild HRIR Converter (RCA Part 1723499) shown on the frontispiece must be used in addition to the modified Fairchild Facsimile Recorder. Modifications to the Fairchild Facsimile Recorder are similar for each mode of operation, only the method of controlling the functions change.

SECTION II

SPACECRAFT AND GROUND STATION PHILOSOPHY

A. GENERAL

The APTS system equipment (spacecraft and ground station) has the facility for displaying real-time, cloud-cover data as transmitted from a meteorological satellite. Usefulness of the APTS system, presently limited to the daytime portion of each orbit, can be increased by modifications designed to permit the reception and processing of HRIR data during the night-time portion of each orbit. Modifications to the spacecraft equipment consist of making the radiometer output compatible with the APTS transmitter and switching the APTS or HRIR subcarrier to the transmitter at the proper time. The HRIR signal differs from the APTS signal as follows; there is no start tone or phasing pulses and the speed (line rate) is incompatible.

B. SPACECRAFT EQUIPMENT

1. General Description

Spacecraft equipment required to obtain a HRIR signal consists of a radiometer and HAX (HRIR/APTS Transmitter) assembly. The relationship of the HRIR equipment, APTS subsystem and transmitter is shown in Figure 1. The radiometer consists of a mirror-scanning mechanism that is rotated through a 360-degree field perpendicular to the orbit track as shown in Figure 2. The radiation from the scan mirror is chopped at a rate of 1500 cps at the focus of a Cassegrainian telescope. It is then focused on to the lead selenide (PbSe) detector by means of a reflective relay containing a gremanium filter. The resultant signal is amplified and demodulated in a synchronous detector using the 1500-cps chopper reference. The video signal is filtered and presented to the processing circuits in the HAX assembly as a voltage between zero volts (for a cold or white scene that corresponds to approximately 4° Kelvin) to minus 6 volts (for a hot or black scene corresponding to approximately 360° Kelvin). The video rate for the Nimbus C radiometer is 1.34 ... seconds per line and is normally presented as 44.715 ... lines per minute. To eliminate the decimal number the line rate is expressed as 5500 lines per 123 minutes (5500/123). On successive Nimbus meteorological satellites the proposed radiometer speed is 48 lines per minute; however, the mission requirements or satellite configuration may dictate radiometer speeds other than those listed.

The radiometer also supplies seven descrete marker pulses that are minus 6 volts in amplitude, 6 milliseconds wide, and separated by a period of 6 milliseconds.

In the HAX assembly the video signal and marker pulses are added resistively, clamped to a d-c reference and amplified. The composite signal shown in Figure 3

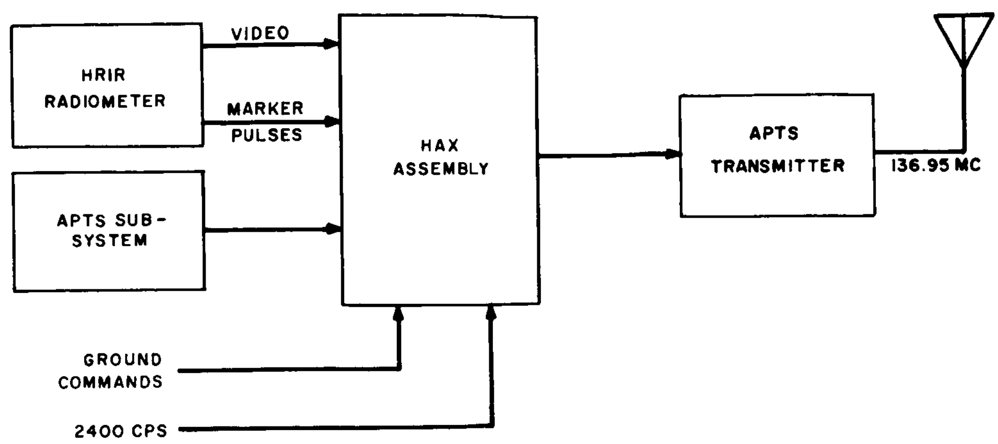


Figure 1. HRIR Spacecraft Equipment Block Diagram

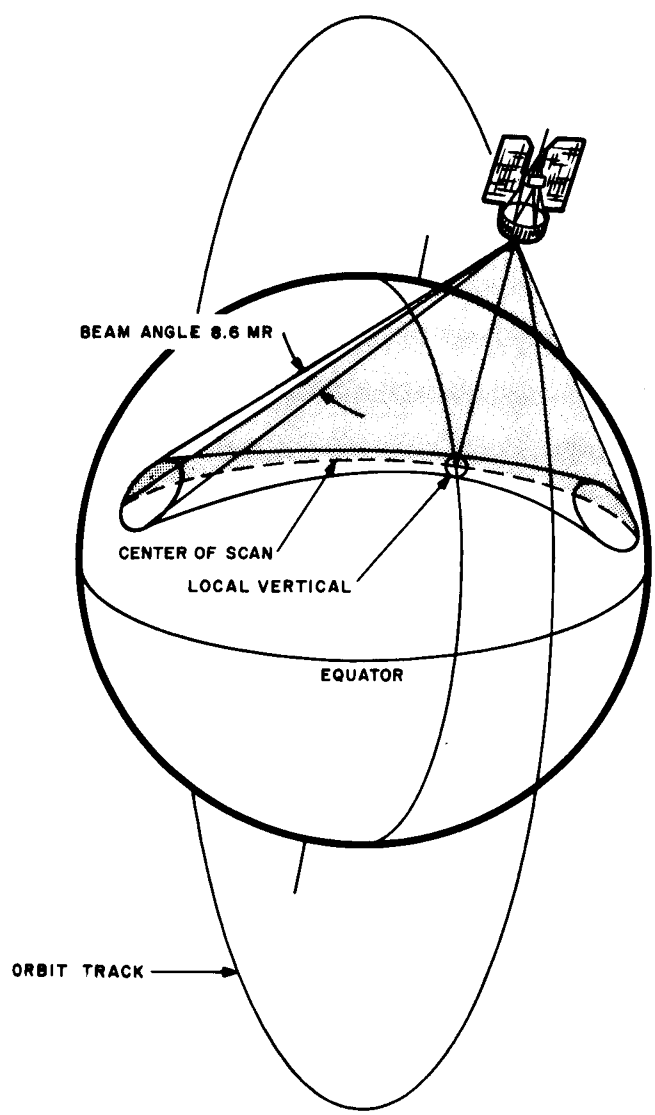
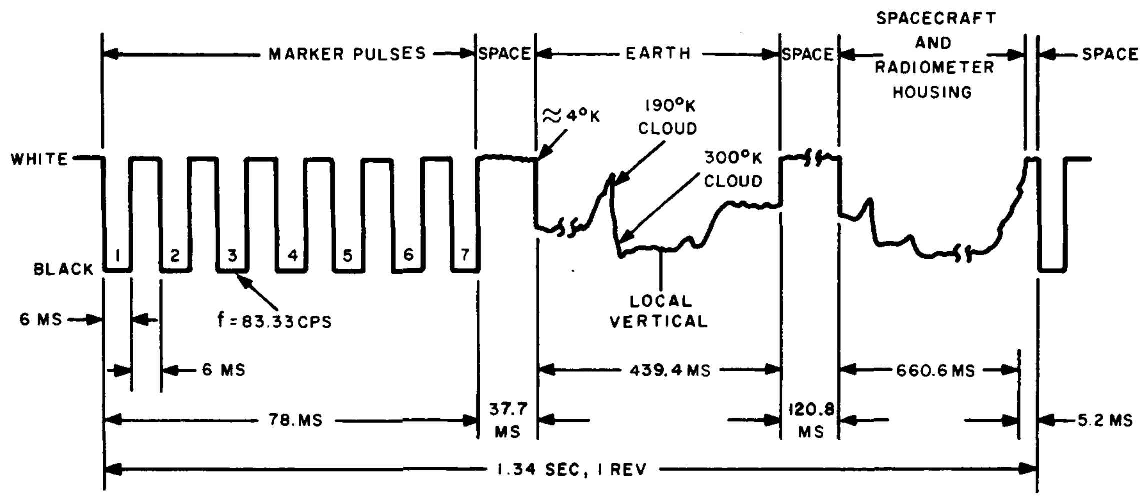


Figure 2. HRIR Scan Pattern



NOTE: THE DURATION OF EARTH AND SPACE SCAN VARIES WITH ALTITUDE. THE VALUES OF TIME SHOWN ARE TYPICAL FOR AN ALTITUDE 0600 NAUTICAL MILES

Figure 3. Composite HRIR-Video Signal

is then applied to a ring modulator that uses the 2400-cps signal from the Nimbus clock as a carrier. The ring modulator, selected because of its demonstrated reliability in the APTS system, supplies a modulated subcarrier to the switching circuits where the output of the selected modulator is supplied to the APTS transmitter. At the ground station the HRIR subcarrier, 136.95 mc, is demodulated and the entire video signal is recorded on the facsimile recorder. A typical facsimile printout is shown in Figure 4. Printing the entire video signal limits the earth scan data to approximately 2.75 inches of the printout; however, the need for blanking circuits and complex-control circuits are eliminated. The position of the earth scan data from the edge of the printout is controlled automatically from picture-to-picture, or it may be changed manually by the operator if necessary. Local vertical is always considered to be at the center of the earth scan data.

2. Spectral Response

The spectral response of the radiometer, 3.4 to 4.2 microns, was selected because atmospheric conditions allow maximum transmission of the signals in this region. The instantaneous field of view is 8.6 milliradians. The spectral response of a typical radiometer is shown in Figure 5 and its relative-amplitude response is shown in Figure 6. (The visible spectrum ranges from about 0.4 to 0.7 microns.)

3. Resolution

The ability of a scanning mechanism to resolve details is limited by the effective beam width and the relationship of the scanned surface and the beam.* When

*There are similar but not identical parameters associated with line-scanning optical systems, therefore, some of the parameters of the radiometer may be analogous to that of a video system.

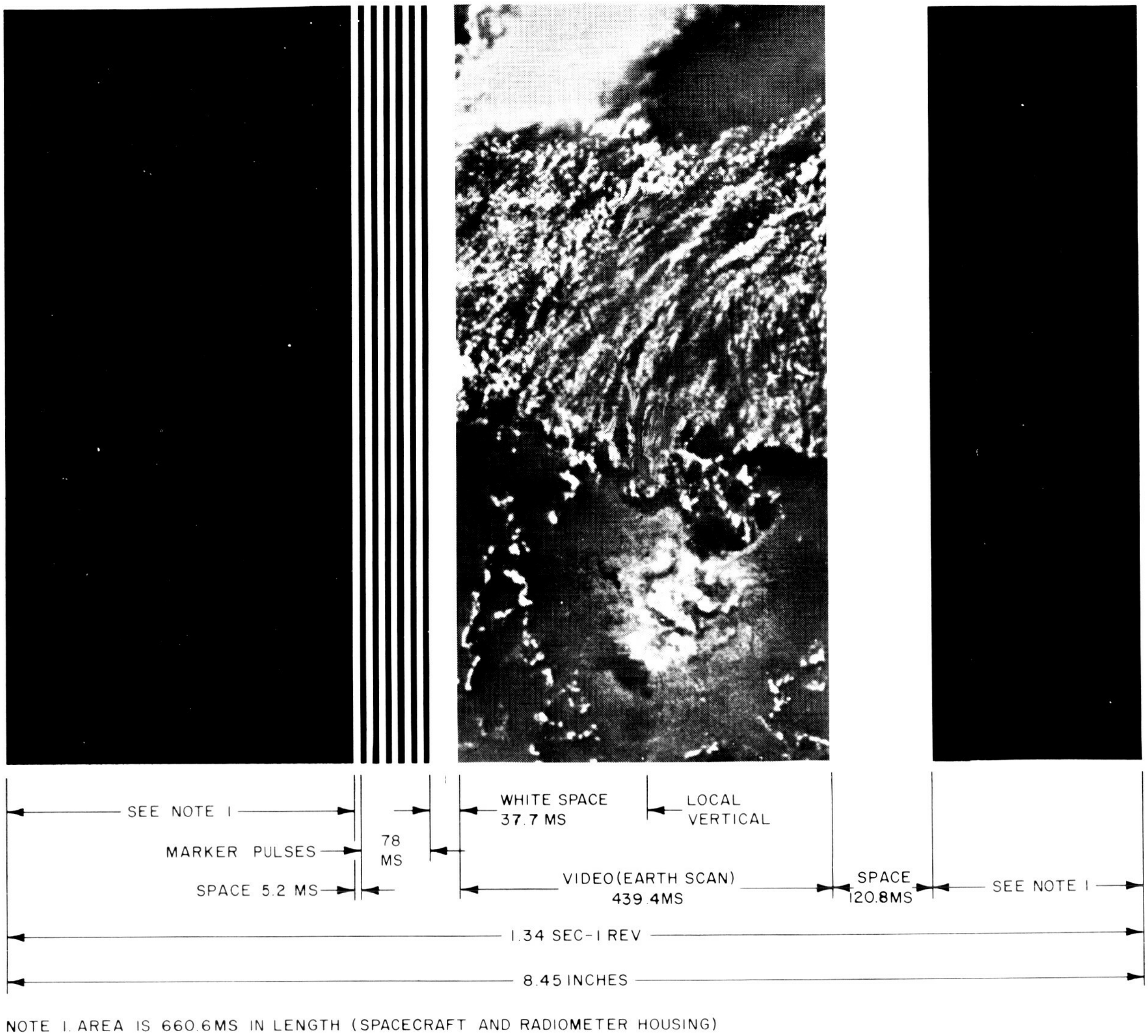


Figure 4. Typical Facsimile Printout

the beam of the radiometer is at local vertical (perpendicular to the scanned surface) the effective beam is circular, the diameter is small as shown in Figure 2, and resolution is optimum. As the displacement of the beam from local vertical increases, the effective beam becomes elliptical, and resolution decreases. Therefore, ground resolution as a function of the scan angle and decreases as the scan angle increases. In terms of scanning geometry, the number of picture elements is

$$\frac{HPN_s}{r} \tag{1}$$

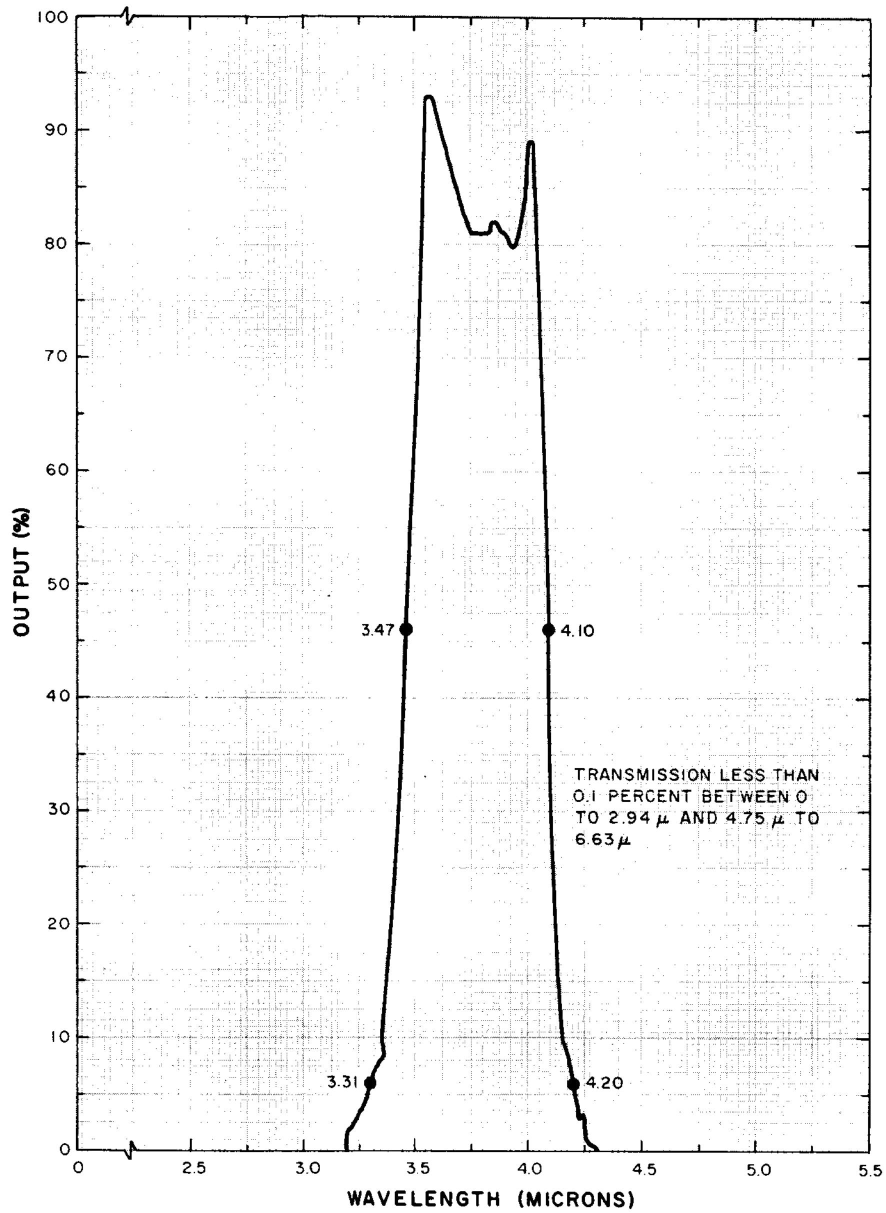


Figure 5. Typical Radiometer Spectral Response

where

H is the altitude of the satellite,

N_S is the radiometer speed in revolutions per unit time,

r is the radius of the Earth,

P is the satellite's circular period at local vertical, expressed as

$$\frac{2\pi (r + H)^{3/2}}{r \sqrt{g}}, \text{ and}$$

g is the acceleration of gravity at the Earth's surface.

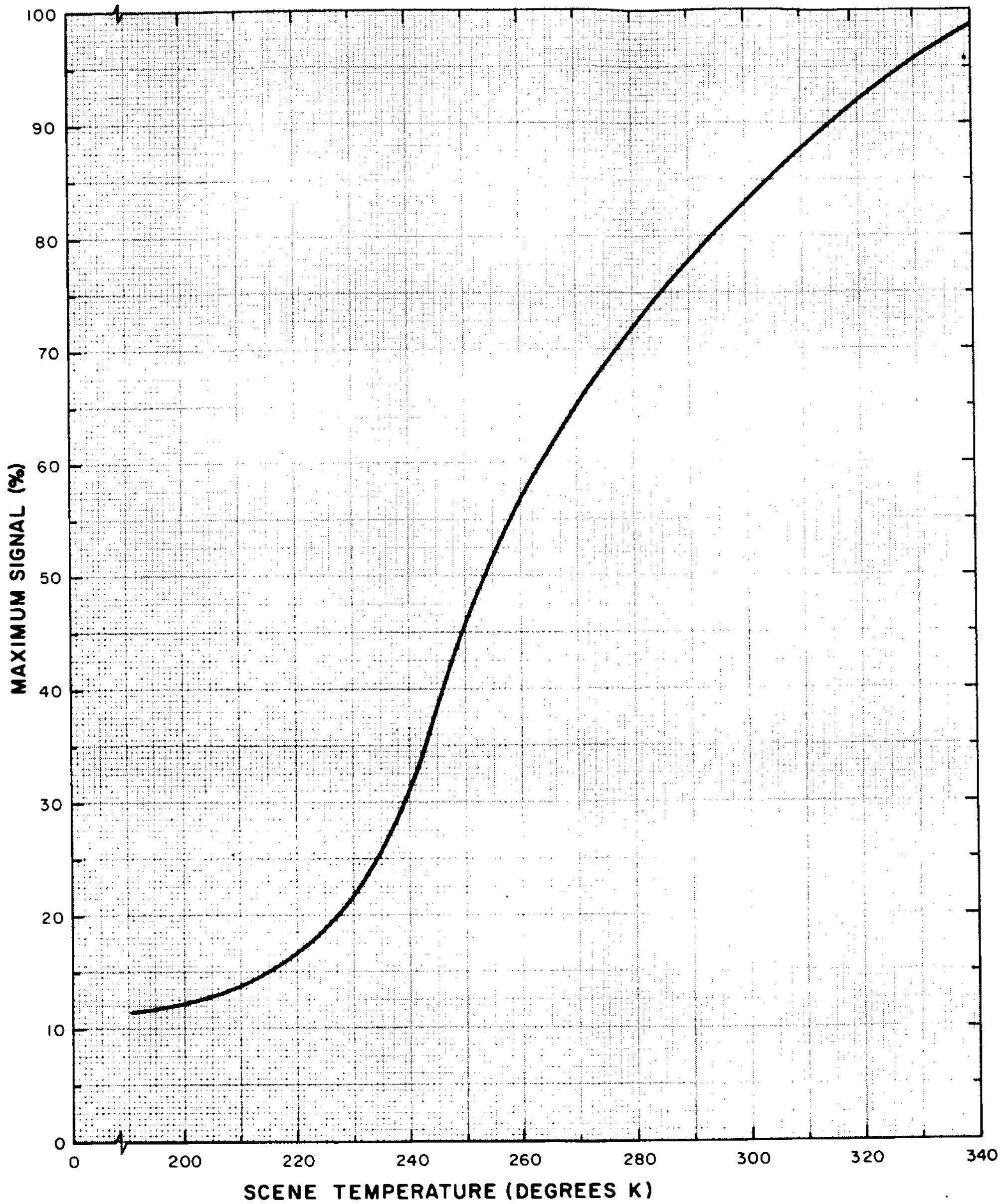


Figure 6. Typical Radiometer Spectral Response

In terms of beam angle, the number of picture elements per facsimile line equals

$$\frac{2\pi}{\omega} \tag{2}$$

where ω is the radiometer beam angle in radians (.0086).

The radiometer may be considered to be optimized when equations (1) and (2) are equal, that is

$$\frac{\frac{2\pi}{\varphi}}{\frac{HPN_s}{r}} = 1. \tag{3}$$

This relationship is satisfied at one altitude only for a given radiometer speed. At a greater altitude, each line will contain information from the previous line. At a lower altitude, information between the lines will be lost. Equation 3 simply states that the width of the scan line cut on the Earth's surface must be equal to the distance traveled by the local vertical during one revolution of the radiometer. Both parts of equation (3) yield values of resolution lower than the resolution available from the facsimile recorder if the altitude is 570 nautical miles or less. Therefore, the recorder resolution, 100 lines per inch, will not effect the resolution of the presentation significantly.

The simple picture of the scanning process is complicated by the curvature of the earth and the fact that the scanning pattern is circular. As the arc of the scan to either side of local vertical increases, so does the area scanned by the radiometer (see Figure 2). As a result, ground resolution decreases and there is an overlap at the extremities of each scan line. The limits for vertical and horizontal ground resolution is expressed as follows:

$$R_v = \frac{\varphi \cdot r \sin \left[\sin^{-1} \frac{(r + H) \sin \Phi}{r} - \Phi\right]}{\sin \Phi}, \tag{4}$$

(when the arcsine is taken as less than $\pi/2$), and

$$R_h = r \left\{\sin^{-1} \left[\left(1 + \frac{H}{r}\right) \sin (\Phi + \varphi)\right] - \sin^{-1} \left[\left(1 + \frac{H}{r}\right) \sin \Phi\right] - \varphi\right\}, \tag{5}$$

where

R_v is the minimum resolvable ground distance parallel to the motion of the satellite (vertical resolution on facsimile paper),

R_h is the minimum resolvable ground distance perpendicular to the motion of the satellite (horizontal resolution on facsimile paper),

r is the radius of the earth,

φ is the field-of-view of the radiometer in radians,

H is the satellite altitude,

Φ is $2\pi x/L$, (angular displacement of radiometer from local vertical)

x is the distance from vertical center to a point of interest in the printout, and

L is the length of a facsimile line (8.45 inches).

The resolvable-earth distance for values of x (the distance from local vertical to a point of interest on a facsimile printout) is shown in Figure 7 for both the vertical and horizontal axis when the altitude is 600 nautical miles. The equivalent displacement of the radiometer is also shown. Note that the minimum resolvable-earth distances for the vertical and horizontal axes are equal at local vertical. As the distance from local vertical increases, the resolvable earth distance per unit length decreases. This is due to the increase of the effective beam width as shown in Figure 2.

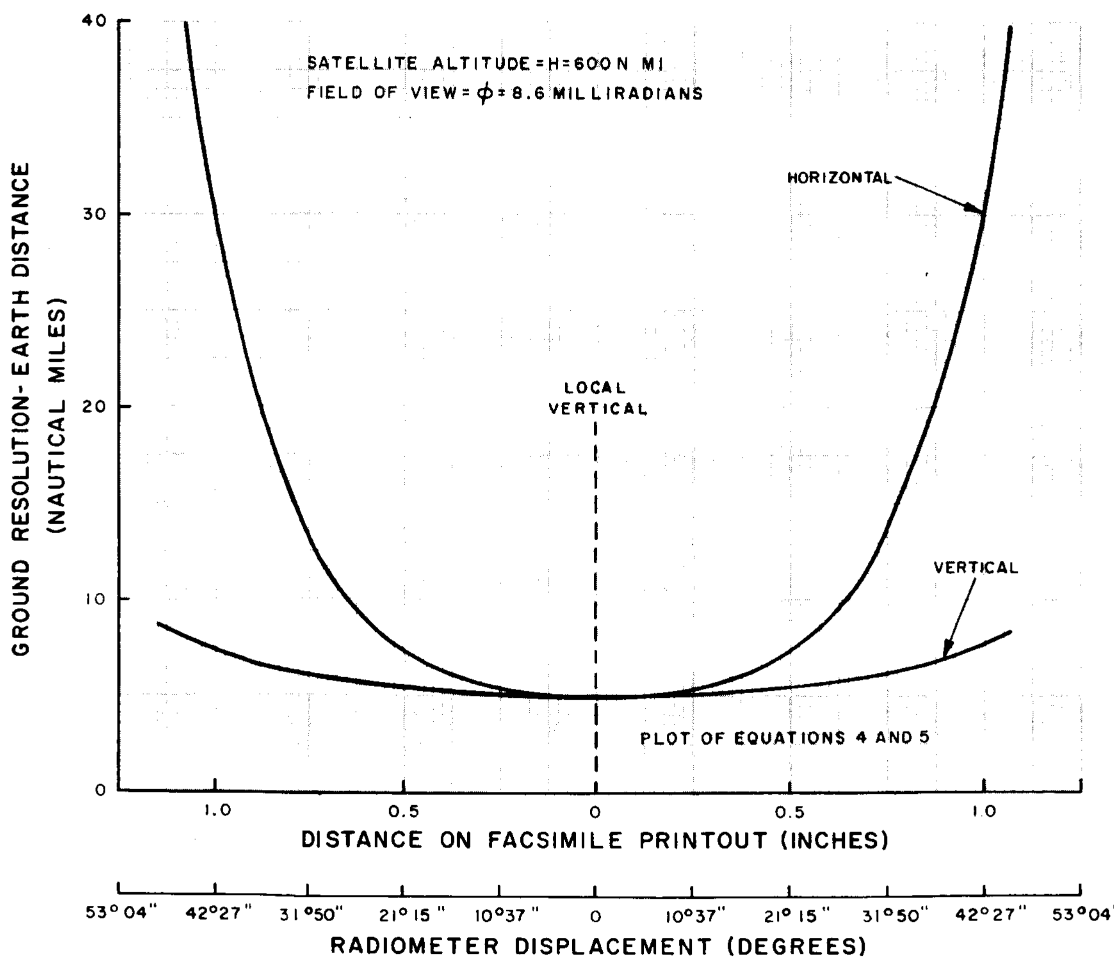


Figure 7. Resolution Versus Position on Facsimile Printout

4. Facsimile Printout Scale Factors

Practical scale factors (distance per unit length on the facsimile printout) vary with altitude and radiometer speed. At any point on the picture the vertical and horizontal scale factors are:

$$\text{Vertical scale factor} = \frac{2\pi}{N_s Pd}\left\{(H + r) - \frac{r \cdot \sin\left[\sin^{-1}\left(\frac{(r + H)}{r} \cdot \sin\Phi\right) - \Phi\right]}{\tan\Phi}\right\} \tag{6}$$

where d = the distance between lines on the facsimile recorder printout,

and

$$\text{Horizontal scale factor} = \frac{2\pi r}{L}\left[\frac{\frac{r + H}{r}\cos\Phi}{\sqrt{1 - \left(\frac{r + H}{r}\right)^2 \sin^2\Phi}} - 1\right]. \tag{7}$$

At local vertical (the center of facsimile printout) equation (6) equals

$$\frac{2\pi r}{N_s Pd}, \tag{8}$$

and equation (7) equals

$$\frac{2\pi H}{L}. \tag{9}$$

The ratio of equations (8) and (9) is

$$\frac{Lr}{HPN_s d}. \tag{10}$$

Ideally, this ratio equals one. A plot of equations (8) and (9) versus altitude, shown in Figure 8, indicates that the ratio [equation (10)] is unity at 600 nautical miles when the radiometer speed is 44.715-----rpm (560 nautical miles for a radiometer speed of 48 rpm). If the spacecraft altitude is 600 nautical miles, a one-inch square at local vertical on the facsimile printout would equal about 450 nautical miles on the side. If the altitude is 800 nautical miles, a one-inch square on the facsimile printout would represent 420 nautical miles on the vertical axis and 695 nautical miles on the horizontal axis. As the altitude of the spacecraft increases, so does the distortion due to change of scale factor.

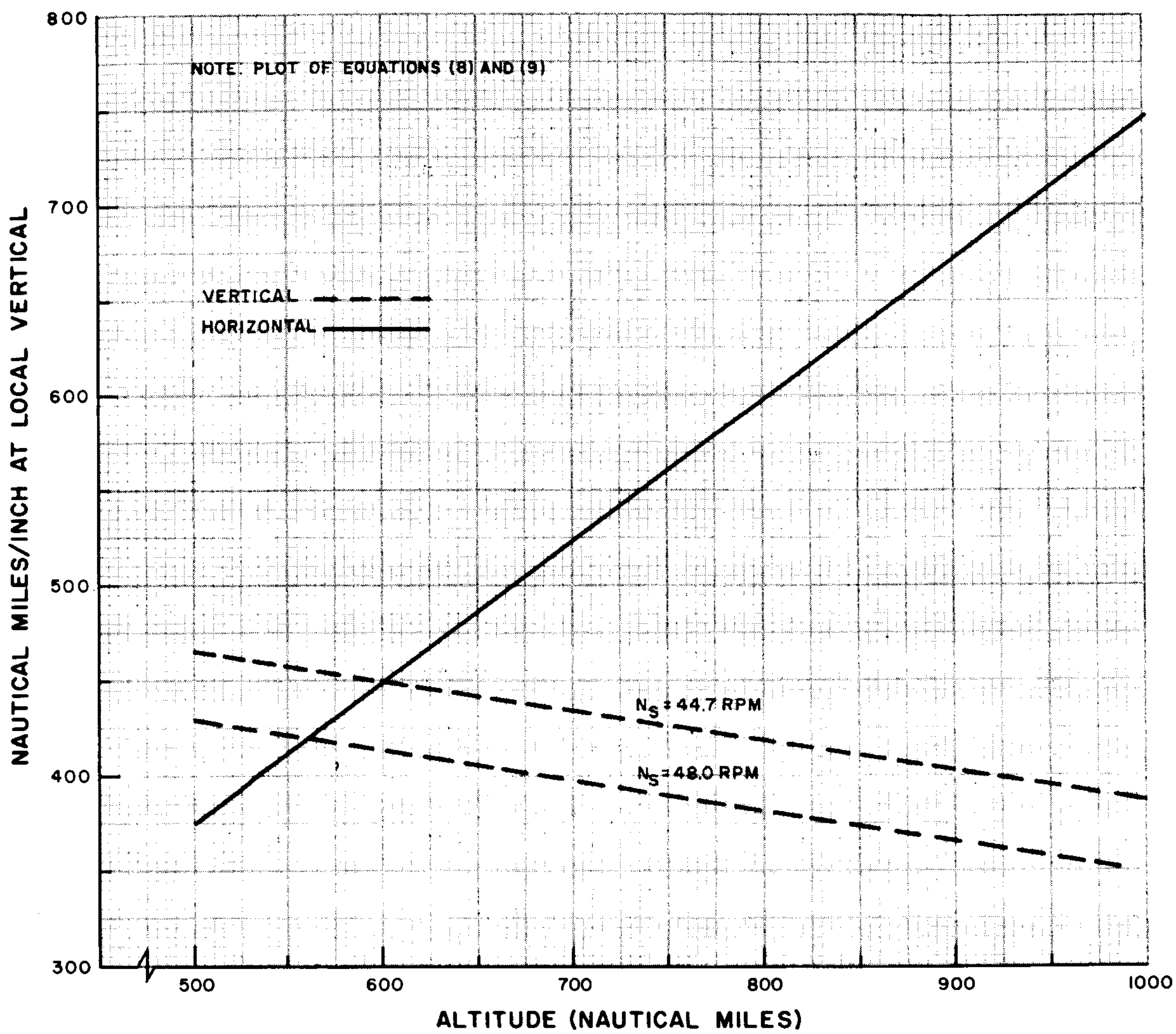


Figure 8. Horizontal and Vertical Scale Factor at Local Vertical

At an altitude of 800 nautical miles, the distance between lines of the facsimile prin. out is equivalent to 4.2 nautical miles. The optimum resolution at 600 nautical mile: is 5 nautical miles per line as shown in Figure 7. From a practical point of view, loss of resolution is not excessive for about 0.6 inch on either side of local vertical (center of earth scan) at this altitude.

The width of the earth scan presentation on the facsimile printout is a function of altitude and equals

$$\frac{\left[\sin^{-1}\left(\frac{r}{r+H}\right)\right] L}{\pi} . \tag{11}$$

The plot of picture width versus altitude shown in Figure 9 may be used to determine the altitude of the spacecraft above local vertical when the printout was made. Once

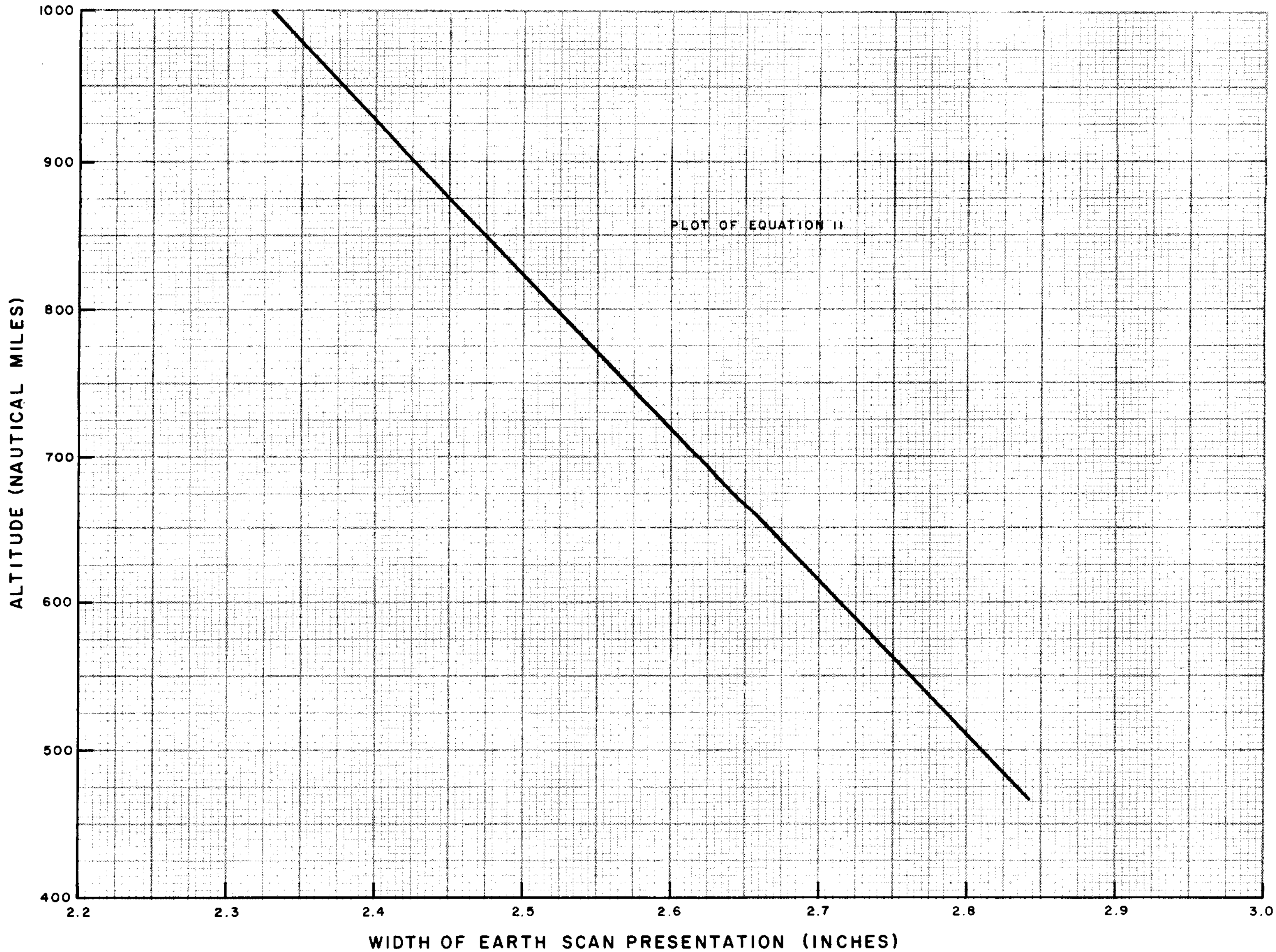


Figure 9. Picture Width Versus Altitude

the altitude is determined (from the facsimile printout or orbital data) the distance along the earth's surface corresponding to a position (x) on the facsimile printout is described as follows:

$$r \left\{ \sin^{-1}\left[\left(\frac{r + H}{r}\right) \cdot \sin \Phi \right] - \Phi \right\}. \qquad (12)$$

A plot of the distance (x) in inches for altitudes of 600, 700, and 800 nautical miles is shown in Figure 10.

C. HRIR SIGNAL PROCESSING

1. General

The facsimile recorder, designed for use with the APTS system has a printout rate of 240 lines per minute. To obtain a useful facsimile printout of HRIR data, one of the following methods may be used:

(1) the HRIR signal speed may be increased to the APTS rate,

(2) the facsimile recorder speed may be decreased to the HRIR rate, or

(3) a camera and oscilloscope may be used.

2. HRIR Signal Speed Increased

The HRIR signal speed may be increased by recording the signal on a tape recorder and increasing the playback speed until the HRIR signal rate is compatible with the APTS rate. When the radiometer speed is 44.715...lines per minute the playback-record ratio must equal 5.36---to 1. When the radiometer speed is 48 lines per minute the playback-record ratio must equal 5 to 1.

For example, if the HRIR signal is recorded at 3.75 ips, the required playback speed is 20 ips, and the frequency components of the signal are increased accordingly. The real-time signal has a 2400 cps carrier with video sidebands to ±300 cps and marker pulse sidebands to ±1600 cps. An ordinary audio tape recorder could store this spectrum with no difficulty. However, for playback, the carrier frequency becomes 12.8 kc with video sidebands ±1600 cps and marker pulse sidebands to ±8.6 kc. This means the frequency response in the playback mode would be 12.8 ±8.6 kc or 4.2 kc to 21.4 kc. Many audio recorders would not be satisfactory over this range. Increasing the HRIR signal speed would also require modifications of the carrier amplifiers and video detectors in the facsimile recorder.

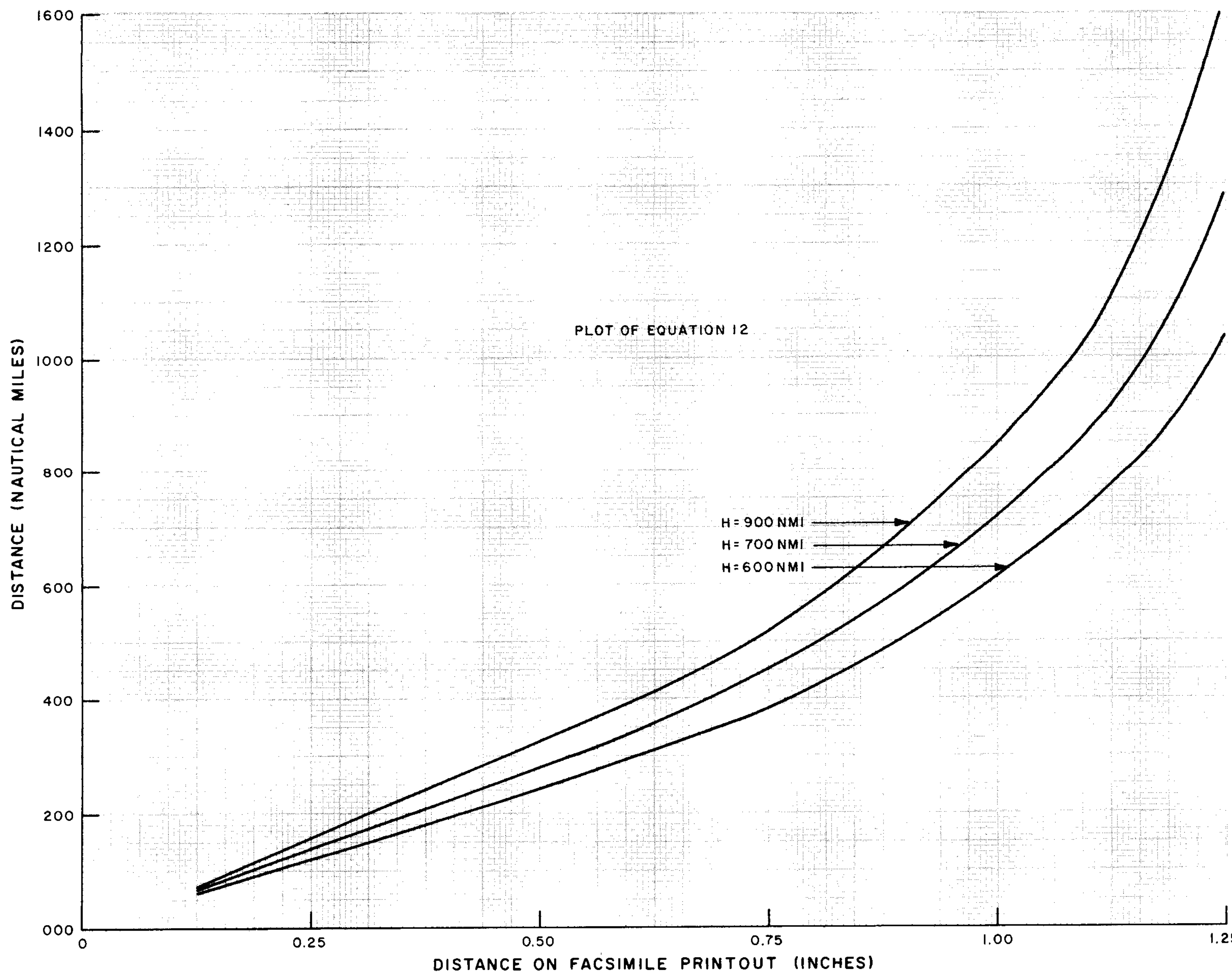


Figure 10. Distance from Local Vertical

Flutter and wow, generated during the record-playback process, causes distortion on the facsimile printout unless some means of correction is employed. One method of correction is obtained by synchronizing the motor-drive signal to the carrier frequency with a phase-locked circuit. Correction can also be obtained by recording the output signal of a tuning-fork oscillator operating at $\frac{240}{5500/123}$ cps (48 cps on later Nimbus satellites) on a second channel of the tape recorder. During playback the recorded signal, not the video subcarrier, would be used to drive the facsimile-recorder drive motor.

3. Facsimile Recorder Speed Decreased

The facsimile-recorder speed may be decreased by using a two-speed motor or a gear box and clutch assembly. In either case, the speed of the facsimile recorder must be reduced from 240 lines per minute to 44.715 lines per minute (48 lines per minute on later Nimbus satellites).

a. TWO-SPEED MOTOR

The speed of the facsimile recorder can be changed by using a motor that operates on two frequencies, thereby providing two speeds. The motor presently used in the Fairchild Facsimile Recorder does not have this capability. When this method is used, the line rate required for HRIR operation must be $\frac{5500/123}{240}$ times (0.2 times for later Nimbus satellites) the line rate required for APTS operation. One method of reducing the line rate is obtained by applying the output of a tuning-fork oscillator directly to the drive motor. Another method of reducing the line rate is obtained by synchronizing the motor drive signal to the subcarrier with the phase-locked circuit shown in Figure 11. This would prevent picture skew even when reproducing tape-recorded signals. When the phase-locked circuit is used, the subcarrier is limited to remove the video components and phase compared with the output of a voltage controlled oscillator. If any phase difference exists, an error voltage from the phase detector will shift the oscillator until the correct phase relationship is obtained. The oscillator output, a steady signal locked-in phase with the input signal, is then divided to produce the correct motor-drive frequency. The low-pass filter keeps the oscillator from responding to rapid signal changes such as noise, transients, or signal dropouts.

b. GEAR-REDUCTION

The facsimile recorder speed can be reduced by using a gear train and clutch assembly which is manually or electrically controlled. The line rate required for HRIR operation is $\frac{5500/123}{240}$ times the APTS rate (0.2 times for later Nimbus

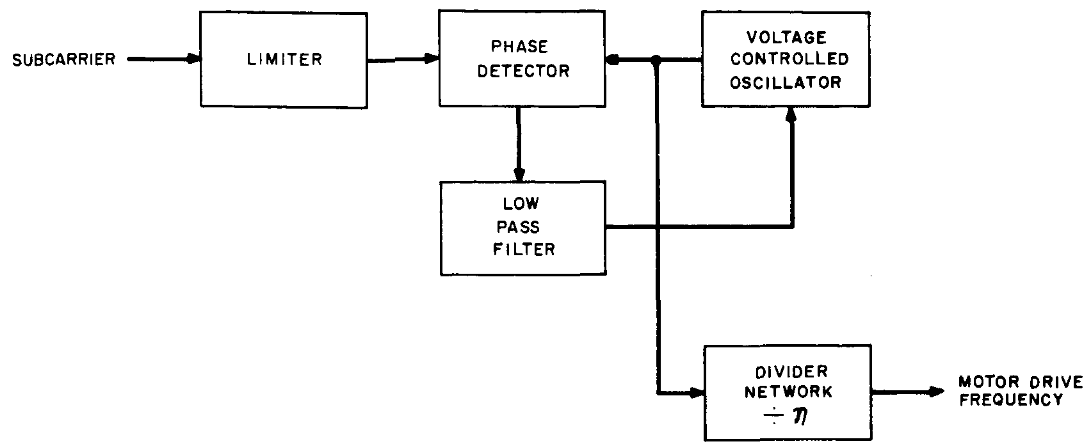


Figure 11. Typical Phase-Locked Motor Drive Circuit

satellites). Use of the gear train and clutch assembly permits the use of the original drive motor and eliminates the need for changes to the facsimile recorder electronics.

The method adopted for use on the APTS ground stations includes the gear-train and clutch assembly because of its simplicity. Technical data required for both the manual and automatic modes of operation is presented in Section III.

4. Oscilloscope and Camera Printouts

An HRIR picture may also be obtained by using an oscilloscope and camera combination. The pictures obtained will be somewhat small in size and lacking in resolution, however, the contrast will be good and they may be useable for some purposes. This approach will require the selection of an appropriate circuit to obtain an oscilloscope display from the incoming HRIR transmission as well as a sweep rate that will provide a picture with minimum distortion.

Since the useful portion of each scan line is approximately 40 percent of the whole line (1.34 seconds for the Nimbus C radiometer) a horizontal sweep rate of the same proportion may be used to obtain as large a picture as possible. Normally a horizontal scan rate of 500 milliseconds per line would be adequate. Once the horizontal sweep rate is selected, the number of vertical lines per inch required for minimum distortion is

$$\frac{740}{y},$$

where

740 = the number of vertical lines required for the length of a horizontal line, and

y = the total horizontal line length, the distance the electron beam of the oscilloscope would travel in 1.34 seconds, not the portion displayed on the oscilloscope.

For clarification, assume that an oscilloscope with a useable scan-area of 3-inches square is avilable and the horizontal sweep rate of 500 milliseconds is selected. The distance (d) the electron beam would travel in 1.34 seconds

$$= \frac{\text{Scan width x scan rate}}{\text{Horiz. Sweep}} = \frac{\text{3 inches x 1.34 sec}}{\text{0.5 sec}} = 8.04 \text{ inches}$$

The number of vertical scan lines per inch equals

$$\frac{740}{y} = \frac{740 \text{ lines}}{8.04 \text{ inches}} = 92.$$

Since the maximum vertical sweep available is 3 inches, the total number of vertical lines is 276(3x92). When the duration of each line is 1.34 seconds the maximum vertical scan required is 370 seconds (1.34 line/sec x 276 lines) or 6.18 minutes. Consequently, the vertical sweep voltage must be adjusted to provide a 3-inch sweep in 370 seconds. The length of the signal (assuming that the altitude is 600 nautical miles and the transmitted signal is available from 10 degrees above the horizon to 10 degrees before the horizon, 10- to 170-degrees) is approximately 11 minutes. With a vertical sweep of 3 inches in 6.18 minutes, only two pictures would be required to record all the information transmitted during one pass.

The electrical circuits required to obtain a printout consist of a receiver, amplitude detector, sync detector, binary counter and a digital-to-analog converter. A motor-driven potentiometer may be used as a substitute for the binary counter and digital-to-analog converter. A block diagram of a typical circuit is shown in Figure 12. When the transmitted signal (136.95 mc) is detected, a 2400-cps, amplitude modulator sub-carrier is applied to the amplitude detector. The amplitude detector, identical to the circuit suggested for the HRIR converter, provides an analog video signal to the Z input of the oscilloscope and the sync detector. The amplitude of the video signal and the intensity of the beam must be adjusted until the black and white signal levels fall within the dynamic range of the oscilloscope. In some cases an additional amplifier may be needed to obtain the proper signal amplitude. The video signal contains very low frequency components, therefore, the detector output (amplifier if used) must be direct coupled to the Z input.

Horizontal sync is detected from the analog video signal with a sync detector similar to the one provided in the HRIR converter. The detected sync pulse triggers the horizontal sweep of the oscilloscope and the vertical sweep control.

Two types of vertical sweep control are shown on Figure 12. The binary counter and digital-to-analog converter would be inexpensive to build as the number of binary stages is small. A count of 276 lines would require 9 stages and a reset gate. A small reduction of 20 lines would reduce the number of stages to 8 and eliminate the gate. If the

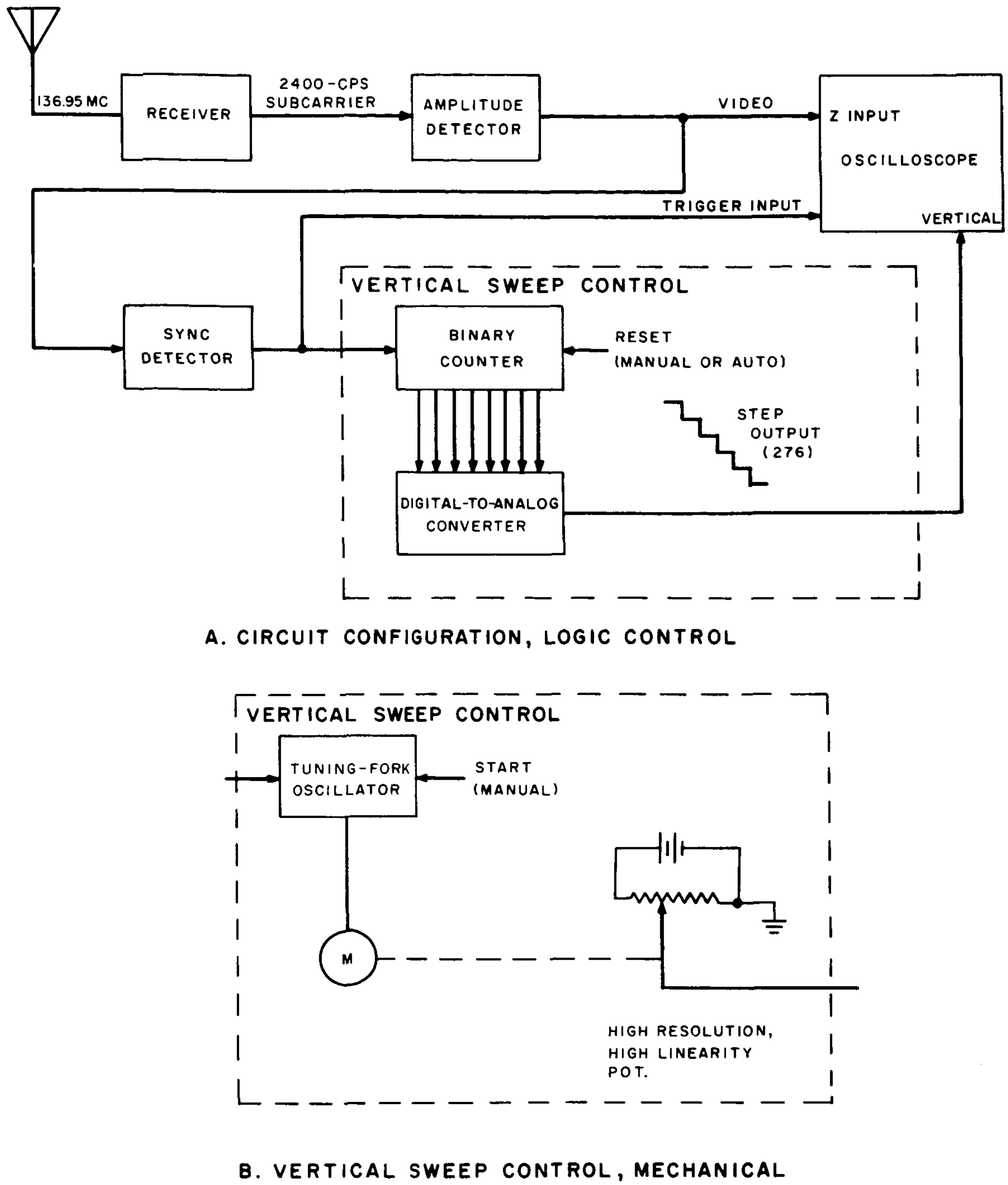


Figure 12. Typical Oscilloscope Control Circuit

horizontal sweep rate is unchanged the amount of geometric distortion is negligible. (To maintain the same picture size when the line rate is reduced to 256 lines, the vertical size should be corrected by 256/276 x 3 inches.) The output of the counter circuit is changed to a step-type signal by the digital-to-analog converter and applied to the vertical-sweep input of the oscilloscope. To determine when the end of the picture is near, a voltmeter can be used to monitor the step-type signal amplitude. The vertical sweep may also be generated with a motor-driven potentiometer controlled by a very stable voltage source. The potentiometer should have a resolution that is ten times greater than the number of lines per vertical sweep. When 276 lines are used a resolution of 0.036 percent (100/ 10 x 276) would be adequate. Linearity of the potentiometer would have to be 0.1 percent or better. The ideal speed of the potentiometer occurs when the wiper makes one revolution during a three inch vertical scan. This speed eliminates the need of a reset mechanism. In the example described the time of one revolution would be 370 seconds. To determine when a picture is complete a pointer and calibrated scale could be attached to the potentiometer.

In actual operation the vertical sweep is started manually when the HRIR is detected (the binary counter will start automatically). Simultaneously, the operator opens the camera shutter and monitors the vertical sweep indicator (voltmeter for binary, pointer for mechanical). When the end of the sweep occurs the shutter is closed the film is advanced, and the shutter is opened again. The amount of information lost will depend on the dexterity of the operator and the simplicity of the equipment. If 5 seconds is required to change the film, a maximum of 4 lines would be lost $\left(\frac{5 \text{ sec}}{1.34 \text{ sec/line}}\right)$. When additional oscilloscopes are available, the operator may devise a scheme where one picture could be taken on each oscilloscope. This would eliminate the loss of any video.

D. APTS GROUND STATION MODIFICATIONS

1. General

Modifications are required because the signal content of the HRIR signal and the APTS signal differs significantly. The APTS signal provided one framed picture every 208 seconds. The first 8 seconds contains a start tone and phasing pulses; the last 200 seconds contains 800 lines of video at 4 lines per second (240 lines per minute). The start tone and phasing pulses signals are used to start the facsimile recorder, provide a reference signal for AGC, and frame (center) the picture on the printout. The HRIR system takes one-unframed (continuous) picture during night-time operation and provides a signal that contains seven marker pulses and video. There is no start tone or phasing pulses and the line rate is 44.715---lines per minute (48 lines per minute for later Nimbus satellites).

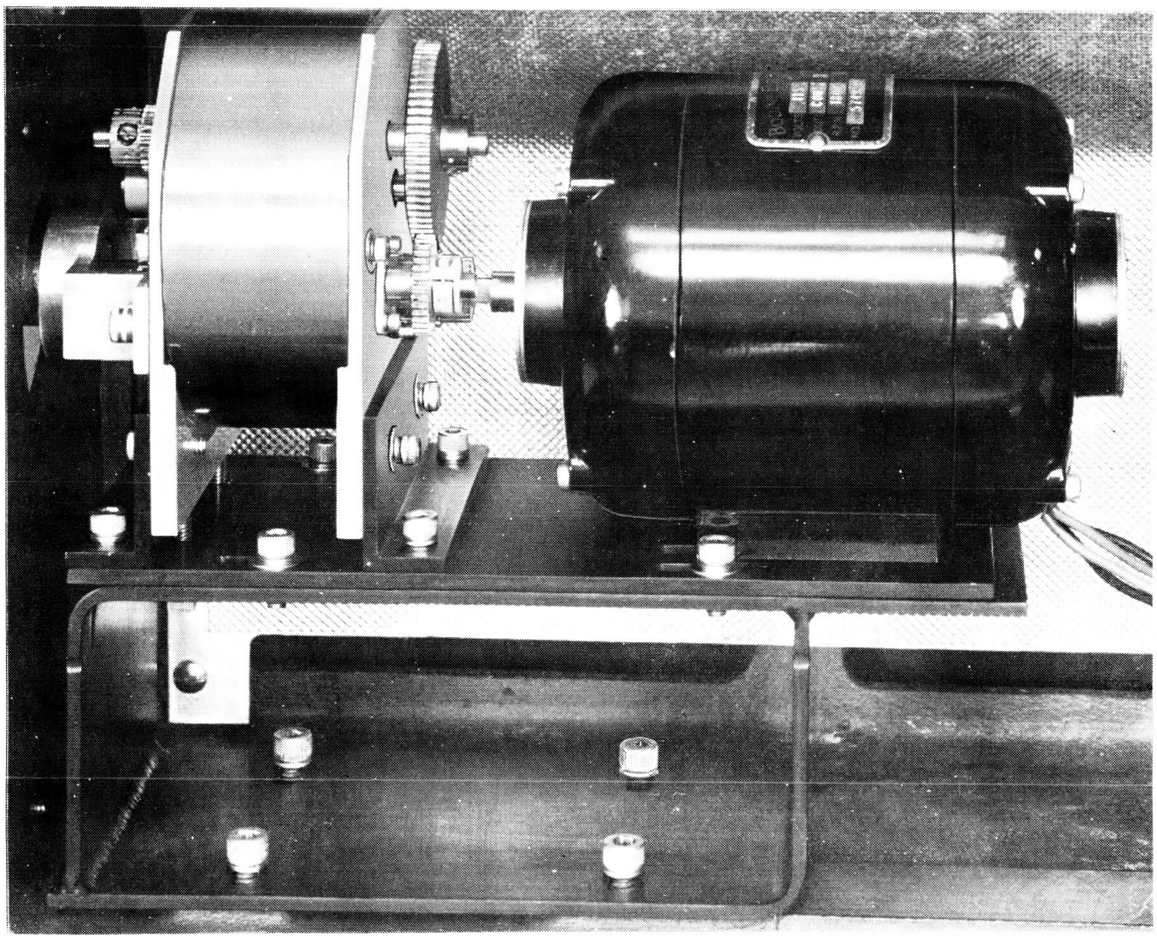
The present facsimile recorder can be utilized by installing a gear train and clutch assembly that provides two speeds of operation, one for APTS printouts and one for HRIR printouts. When the facsimile-recorder speed is reduced for HRIR printouts, the writing current will have to be reduced otherwise the printout will burn when black-level signals are received.

Finally, the facsimile recorder must be controlled. Control can be initiated automatically as in the APTS mode if an HRIR converter is available. This unit contains circuits that detect the marker pulses (see Figure 3) and generate the necessary start, phasing, and AGC signals. Although these functions are essential for a completely automatic system, they may be dispensed with in the interest of economy. In this case, the facsimile recorder can be phased and the gain control can be adjusted by using the manual controls provided on the facsimile recorder. Requirements for both the manual and automatic modes of operation are presented separately.

2. Facsimile Printouts, Manual Mode

Modifications required for the manual mode of operation consist of the gear train and clutch assembly shown in Figure 13 and a control that changes the writing current and selects the proper operating speed. The gear ratio required for HRIR printouts must reduce the facsimile-recorder speed so that it equals the radiometer speed. The radiometer speed in the Nimbus C satellite is 5500/123 rpm. To obtain this speed, the gear ratio must reduce the facsimile-recorder speed by the following ratio,

$$\frac{5500/123}{240}$$



65-8-36

Figure 13. Gear Train and Clutch Assembly

Future Nimbus satellites may use a radiometer speed of 48 rpm, in this case the gear ratio must reduce the facsimile recorder speed by 0.2.

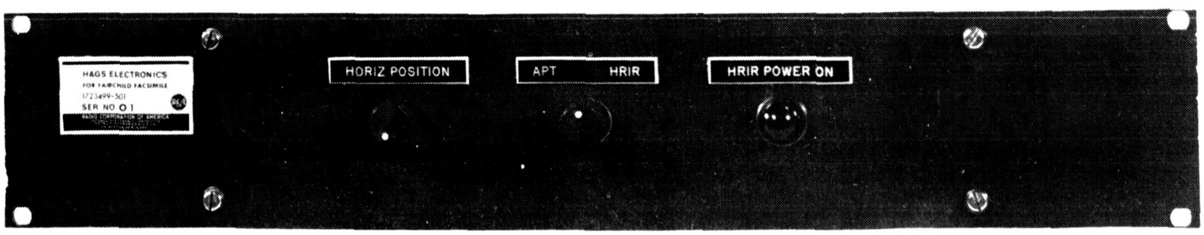
Since the helix rotates at approximately one-fifth the APTS rate, the marking current must be reduced to prevent burning of the facsimile paper when black-signal levels are received. Marking current for HRIR operation shall be 58 ±1.5 milliamperes compared to 170 ±5.0 milliamperes for APTS operation. The marking current is controlled by connecting a dropping resistor and the normally closed contacts of a switch in parallel. The parallel combination is connected into the marking circuit so that the dropping resistor is bypassed during APTS operation. During HRIR operation, the switch is opened and the dropping resistor is switched into the marking circuit thereby reducing the writing current. A second set of contacts on the switch is used to control the clutch on the gear train. Control of the facsimile recorder (starting, phasing, and automatic gain control) is performed manually as described in the "Automatic Picture Transmission Ground Station, Installation, Operation, and Maintenance Manual," issued by Fairchild Stratos, on March 15, 1963.

3. Facsimile Printout, Automatic Mode

Modifications for the automatic mode of operation consist of the gear train and clutch assembly shown in Figure 13 and the HRIR converter shown in Figure 14. The gear train and clutch assembly is identical to the unit described for the manual mode of operation. Control of the facsimile recorder is a function of the HRIR converter which detects the HRIR signal and generates the necessary control signals.

During the APTS operation, the 300-cps start tone is used to start the facsimile recorder. The HRIR signal does not contain a 300-cps start tone, therefore another means of starting the facsimile recorder must be used. The presence of the marker pulses may be used to simulate the start tone if a detector with good discrimination is used. When the start function is complete, phasing and AGC can be performed.

The phasing and AGC functions of the facsimile recorder are dependent on phasing pulses contained in the APTS signal. Since the HRIR signal does not contain phasing



65-10-166

Figure 14. HRIR Converter Assembly

pulses, another method of providing this function is required. For automatic phasing, the marker pulses are detected, shaped to simulate APTS phasing pulses, and injected into the facsimile-recorder circuits. The facsimile-recorder circuits compare the phasing pulses with the signal received from a cam-operated switch on the helix shaft. When the pulses coincide the speed of the helix shaft, reduced during the phasing cycle, is returned to normal. At this time the video is correctly phased (centered on the printout) and the phasing cycle is terminated.

Automatic gain, provided by a motor-driven potentiometer and comparator, is dependent on the white level of the phasing pulses during APTS operation. During HRIR operation, a white level signal (space-white) suitable for AGC control is available after each earth scan. See Figure 3. To insure that AGC occurs during the space-white interval, the marker pulses are detected and used to generate a sample signal. The sample signal, delayed 560 milliseconds from the beginning of the marker pulses, enables the AGC circuits when the space-white signal is present. During the remainder of each line the AGC circuits are disabled.

SECTION III

TECHNICAL DATA

A. GENERAL

The data in this section pertains only to new RCA equipment (the HRIR converter, adapter harness, extender cable) and RCA modifications to the facsimile recorder. An interconnection diagram is shown in Figure 15. For information concerning the remainder of the ground station, refer to the "Automatic Picture Transmission Ground Station, Installation, Operation, and Maintenance Manual," issued by Fairchild Stratos on March 15, 1963.

B. ENGINEERING DRAWINGS

Engineering drawings required to explain and illustrate the modifications and additional equipment (HRIR Converter and Extender Cable) are listed in Table 1 and presented at the end of this document.

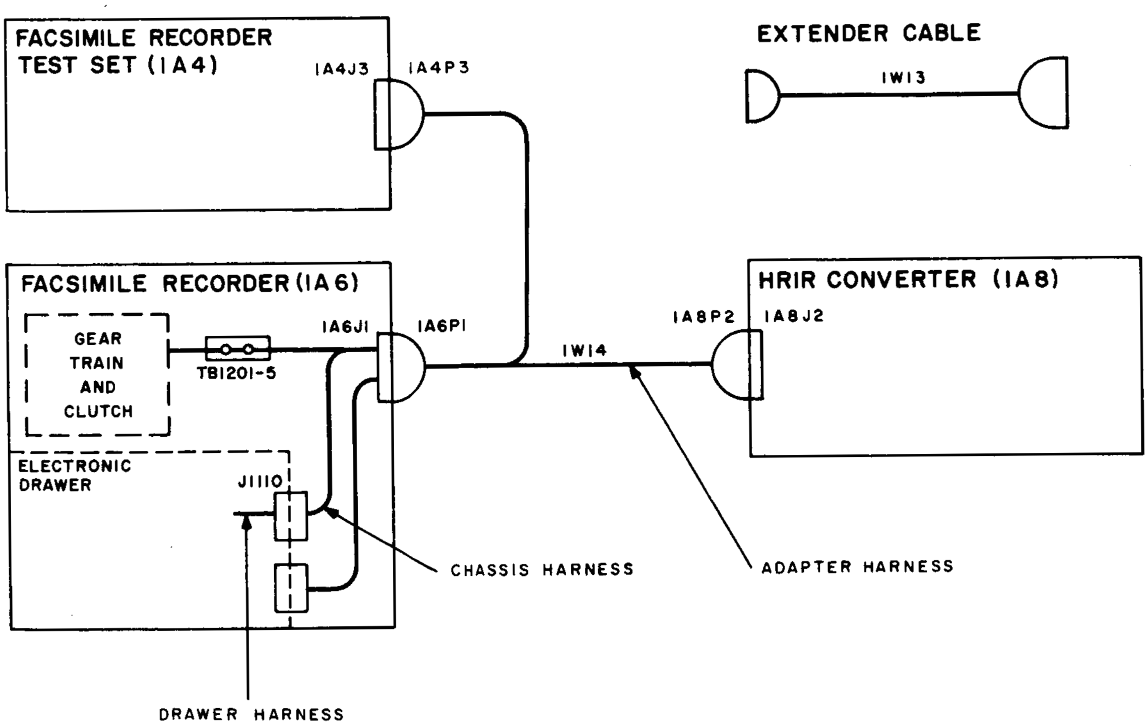


Figure 15. Facsimile Recorder and HRIR Converter Interconnections

TABLE 1. ENGINEERING DRAWINGS

Unit and Drawing Description	RCA Drawing No.	Figure No.
Fairchild Recorder System	1848093	
Facsimile Recorder Assembly	1843778	28
Extender Cable (1W13)	1848252	29
Harness Assembly, Chassis	1848265	30
Installation and Harness Assembly	1843736	31
Harness Assembly, Drawer	1848261	32
Reduction Gear Assembly	1723737	33
Motor	1848220	34
Bearing Plate	1843724	35
Spacer	1847061	36
Gear Housing	1848212	37
Shaft	1847063	38
Base Plate	1843722	39
Mounting Bracket	1843723	40
Spur Gear, 41 teeth	1847062	41
Stand-off	1847060	42
Bearing Retainer	1847064	43
Bracket	1848213	44
Adapter, Gear to Clutch	1848208	45
Spur Gear, 25 teeth	1848209	46
Bearing Retainer	1848216	47
Shaft	1847069	48
Adapter Harness (1W14)	1848271*	49
HRIR Converter		
Assembly	1723499	50
Schematic	1723763	51
Power Supply Assembly (A1)	1843492	52
Component Board Assembly (A2)	1843905	53

*View A on this drawing is a suggested method of assembling a coax cable

C. FACSIMILE RECORDER MODIFICATIONS

1. General

Modifications to the facsimile recorder consist of a gear train and clutch assembly, chassis harness, and drawer harness. The drawer harness provides the interface between the existing circuits in the facsimile recorder and the new circuits in the HRIR converter. The description of all the new components added to the facsimile-recorder drawer is provided. The chassis harness connects the clutch and electronics circuits to the adaptor harness via connector 1A6J1. The gear train and clutch assembly provide the means of reducing the facsimile recorder line rate until it is compatible with the HRIR line rate. Modifications for the facsimile recorder can be classified into two groups, those required for the manual mode of operation and those required for the automatic mode of operation. Modifications required for the manual mode, representing the minimum expenditures required for the reception and processing of HRIR data, are presented in Paragraphs 2 and 3. Modifications required for the automatic mode of operation are presented in Paragraphs 2, 4, 5, and 6 and shown on Figure 28.

2. Gear Train and Clutch Assembly

A detailed view of the right- and left-hand side of the gear train and clutch assembly is shown in Figures 16 and 17. Details of the installation and motor drive are also shown. The gear train provides the two speeds required to produce APTS or HRIR signals on the facsimile recorder. The clutch provides the means of selecting either speed with a control switch. During APTS operation, the clutch is deenergized and the input-output ratio is 1 to 1. Power is then transferred through the clutch, the inner shaft, and gear No. 7 (see the solid arrows in Figure 18). When the clutch is deenergized, the outer shaft is floating (no power transfer). During HRIR operation the clutch is energized and power is then transferred through gear Nos. 1 through 6, the outer shaft, the inner shaft, and gear No. 7 (see the dashed lines in Figure 18). When the clutch is energized, the motor-drive input shaft is disconnected (floating) and the outer shaft is locked to the inner shaft. The exact input-output ratio must be equal to the APTS/HRIR line ratio, namely:

$$\frac{\text{APTS rate}}{\text{HRIR rate}} = \frac{240}{5500/123} \quad \text{(5.0 for later Nimbus satellites).}$$

The number of teeth in gears 1, 3, 4, and 6 are selected until

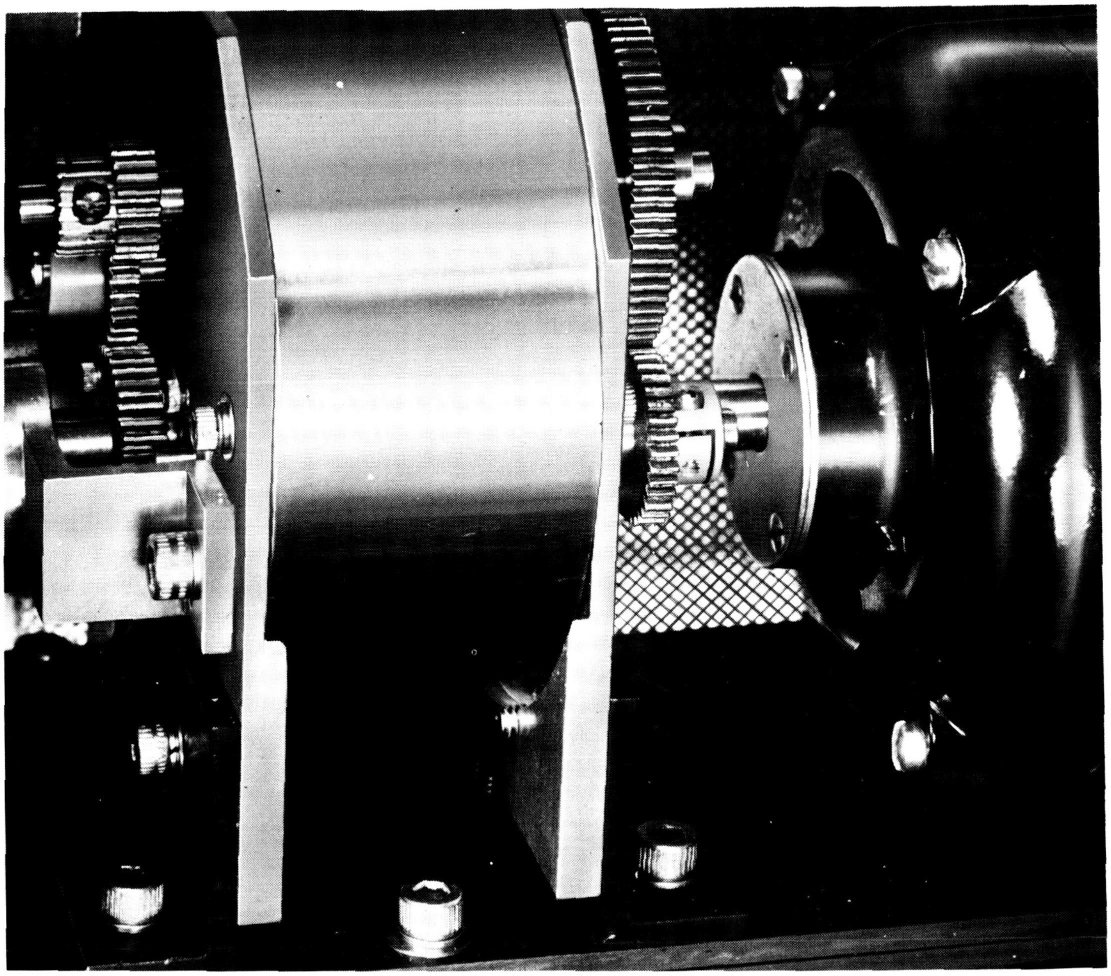
$$\frac{N_6}{N_4} \times \frac{N_3}{N_1} = \frac{41}{22} \times \frac{72}{25} = \frac{2952}{550} = 5.3672 \text{ ---}$$

where N is the number of teeth.

It does not matter how many teeth are on the idler gears, Nos. 2 and 5, as they cancel out when the gear ratios are computed. The engineering drawings of the gear train and clutch assembly are shown in Figures 33 through 48.

3. Marking Current and Clutch Control, Manual Mode

During the HRIR mode of operation it is necessary to reduce the marking current to 58 ± 1.5 milliamperes and energize the clutch. The marking current is



65-8-34

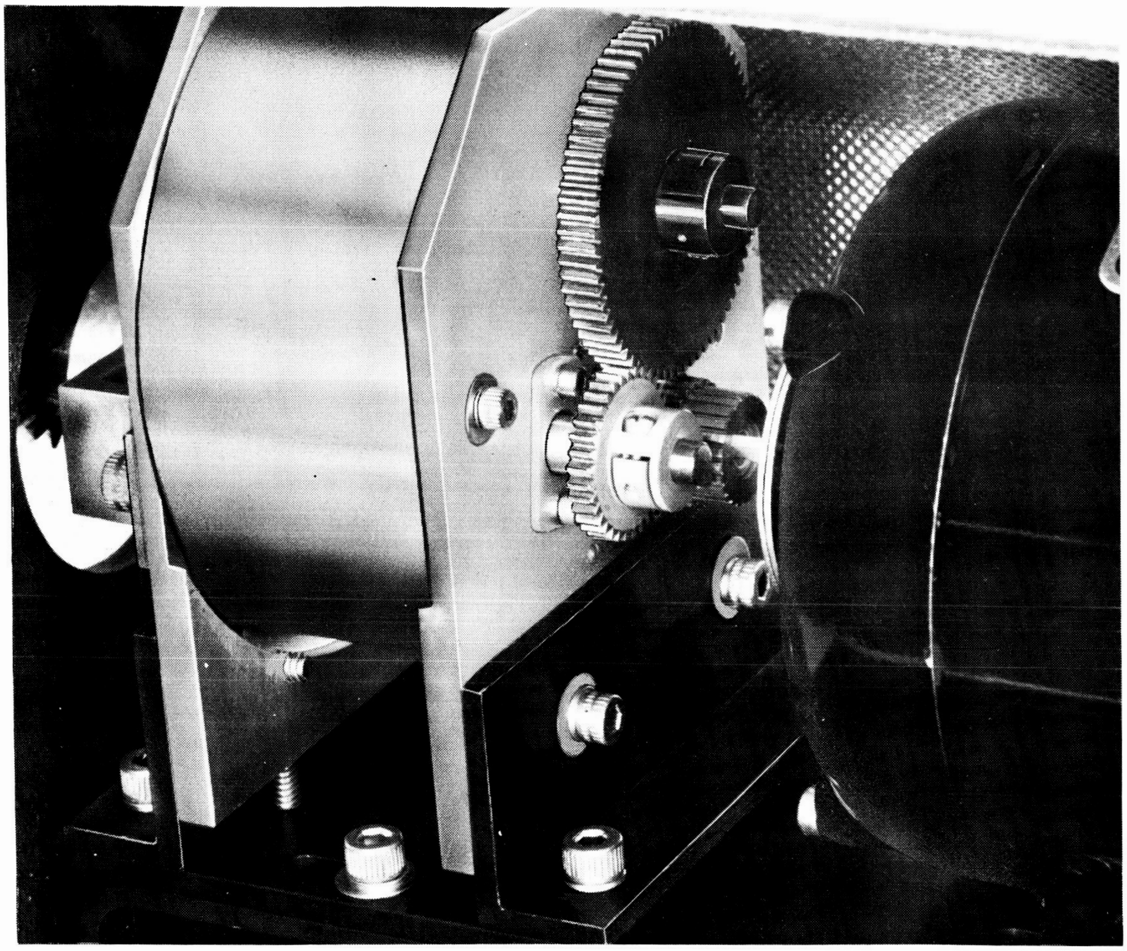
Figure 16. Gear Train Drive, Left Side

reduced by placing a 4-watt dropping resistor between resistors R118 and R128 in the facsimile recorder as shown in Figure 19. If a fixed resistor is used, the resistance (less than 25 ohms) is selected during test until the specified marking current is obtained. The use of a linear potentiometer would provide a convenient method of making periodic adjustments.

Once the dropping resistor is installed, the marking-current level is switched with a DPDT switch connected in parallel with the dropping resistor. When the switch is in the HRIR position, the dropping resistor is in the circuit and the clutch is energized.

4. Drawer Harness

The drawer harness provides the means of connecting the new circuits of the HRIR converter to the existing circuits in the facsimile drawer. It consists of a 14-wire



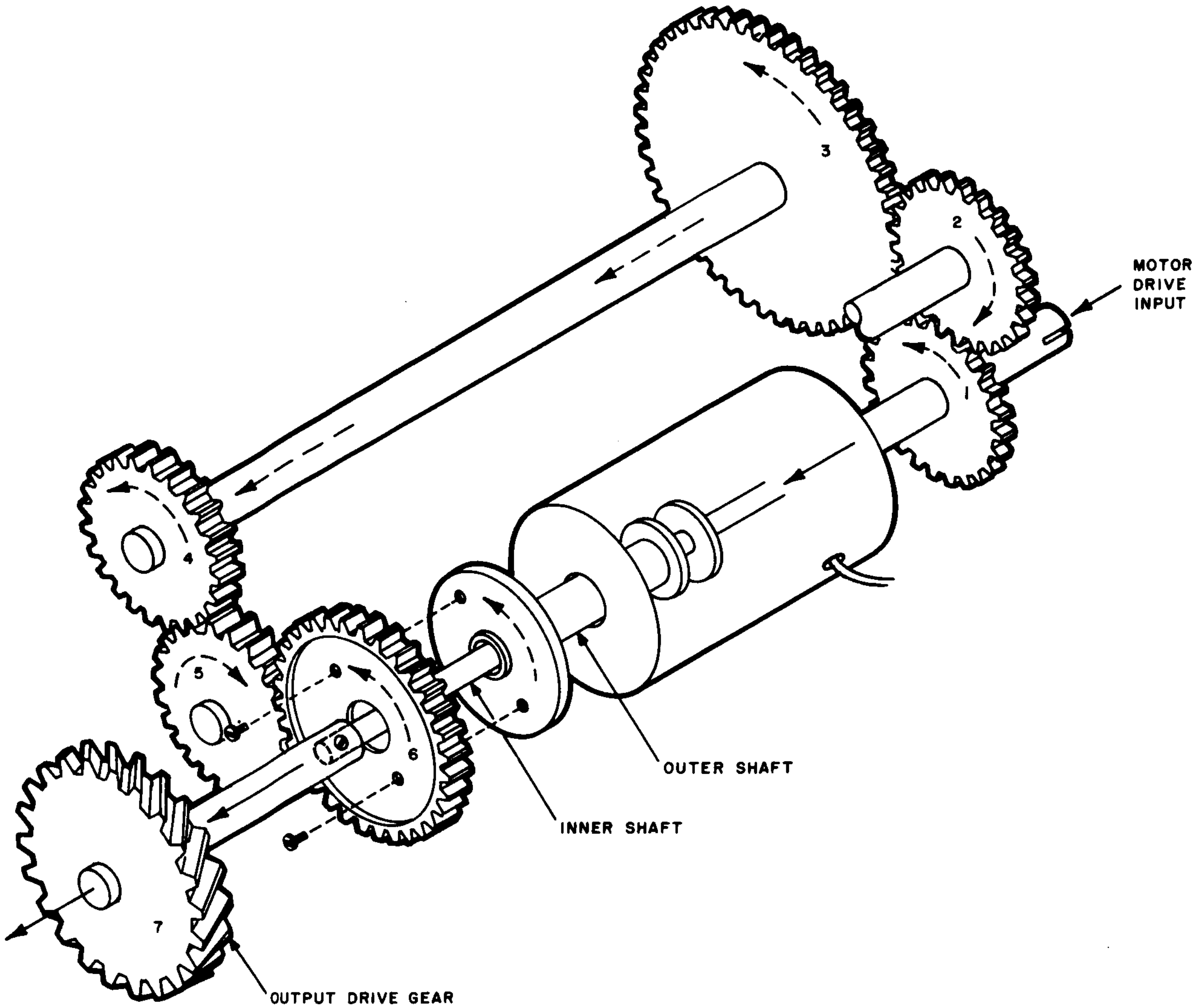
65-8-37

Figure 17. Gear Train Drive, Right Side

harness connected to jack J1110. Jack J1110, shown in Figure 20 mates with plug P1110 on the chassis when the drawer is closed. Electrical connections are shown in Figure 21 where small portions of the existing schematic (Figure 6-31 in the "Automatic Picture Transmission Ground Station, Installation, Operation and Maintenance Manual") are reproduced. The mechanical layout, showing the location of the affected components and the connections, is shown on Figure 31. Details of the drawer harness are shown on Figure 32.

5. Chassis Harness

The chassis harness provides circuit continuity between the facsimile-recorder electronic drawer and the facsimile-recorder chassis. Electrical connections for the chassis harness are shown in Figure 21. A typical installation is shown in Figure 22. Outline and assembly information is shown in Figure 30.



GEAR NUMBER	1	2	3	4	5	6	7
NUMBER OF TEETH	25	34	72	22	34	41	16

——→ APTS DRIVE-RATIO = 1:1
– – → HRIR DRIVE-RATIO = 1:267/1476

Figure 18. Gear Train Schematic

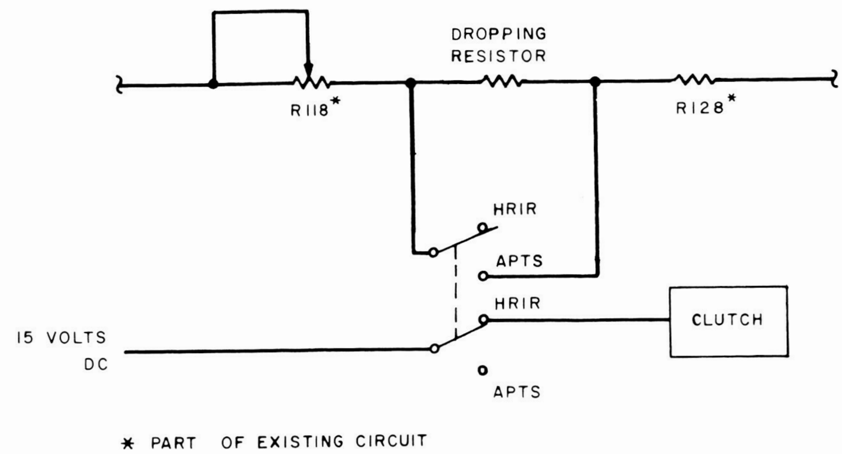
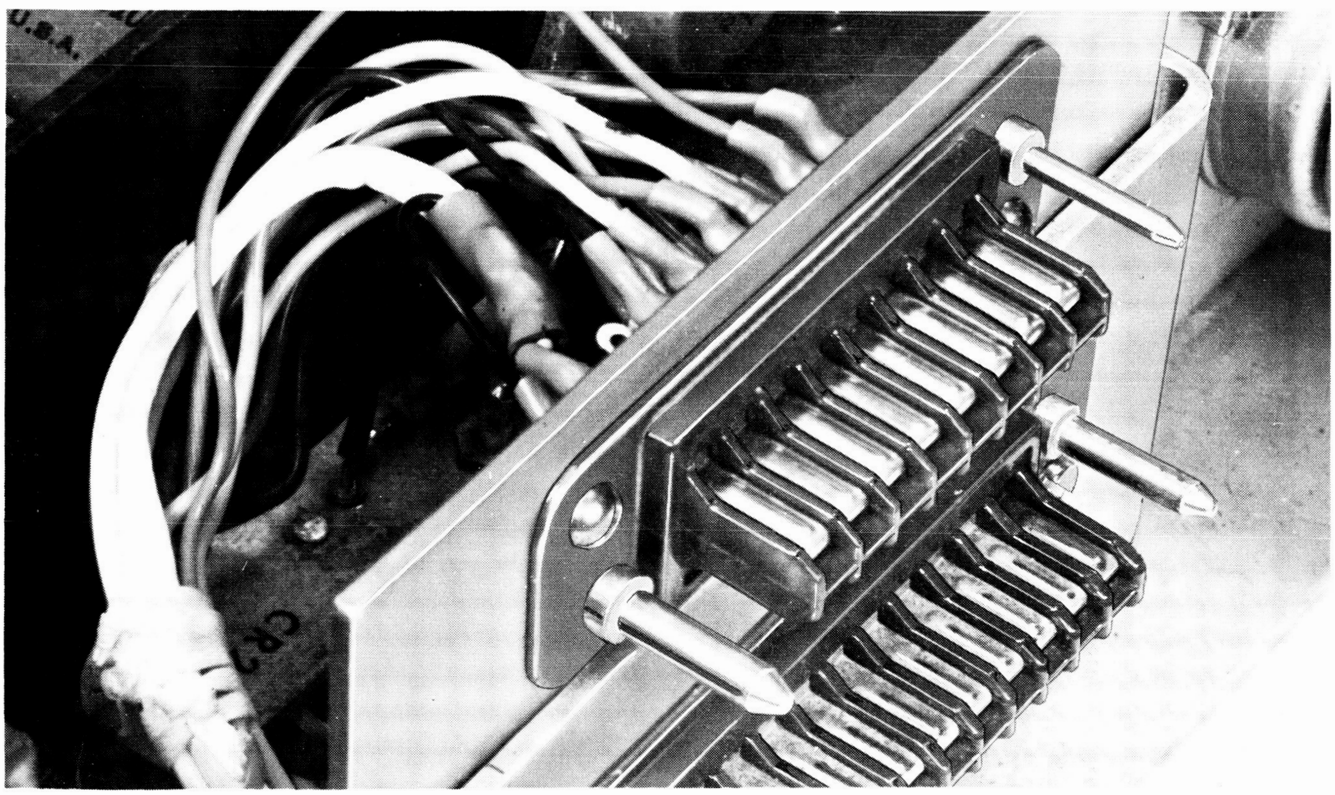


Figure 19. Marking Current and Clutch Control Circuit, Manual Mode



65-8-43

Figure 20. Jack J1110 Installation

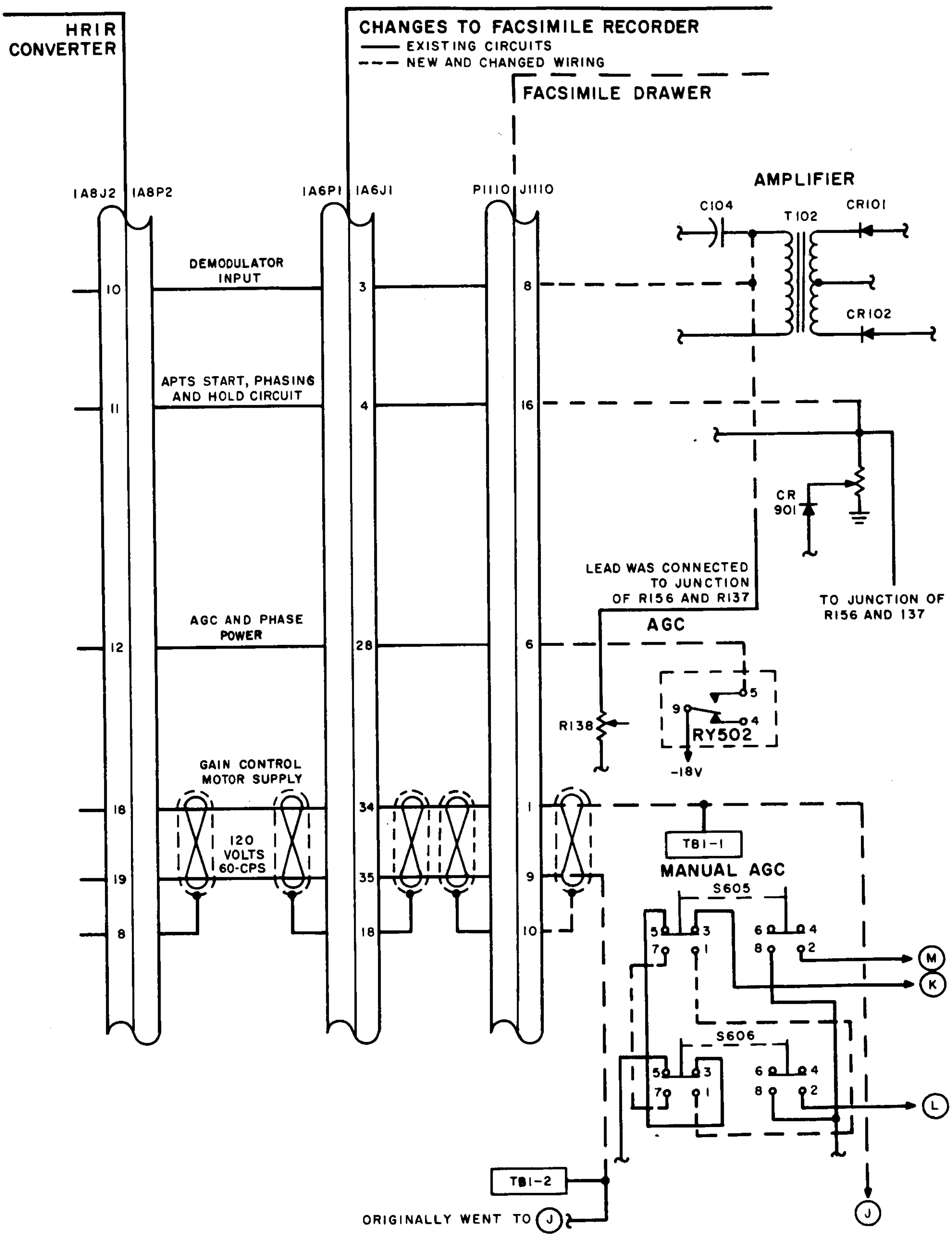


Figure 21. Circuit Modifications for Facsimile Drawer (Sheet 1 of 3)

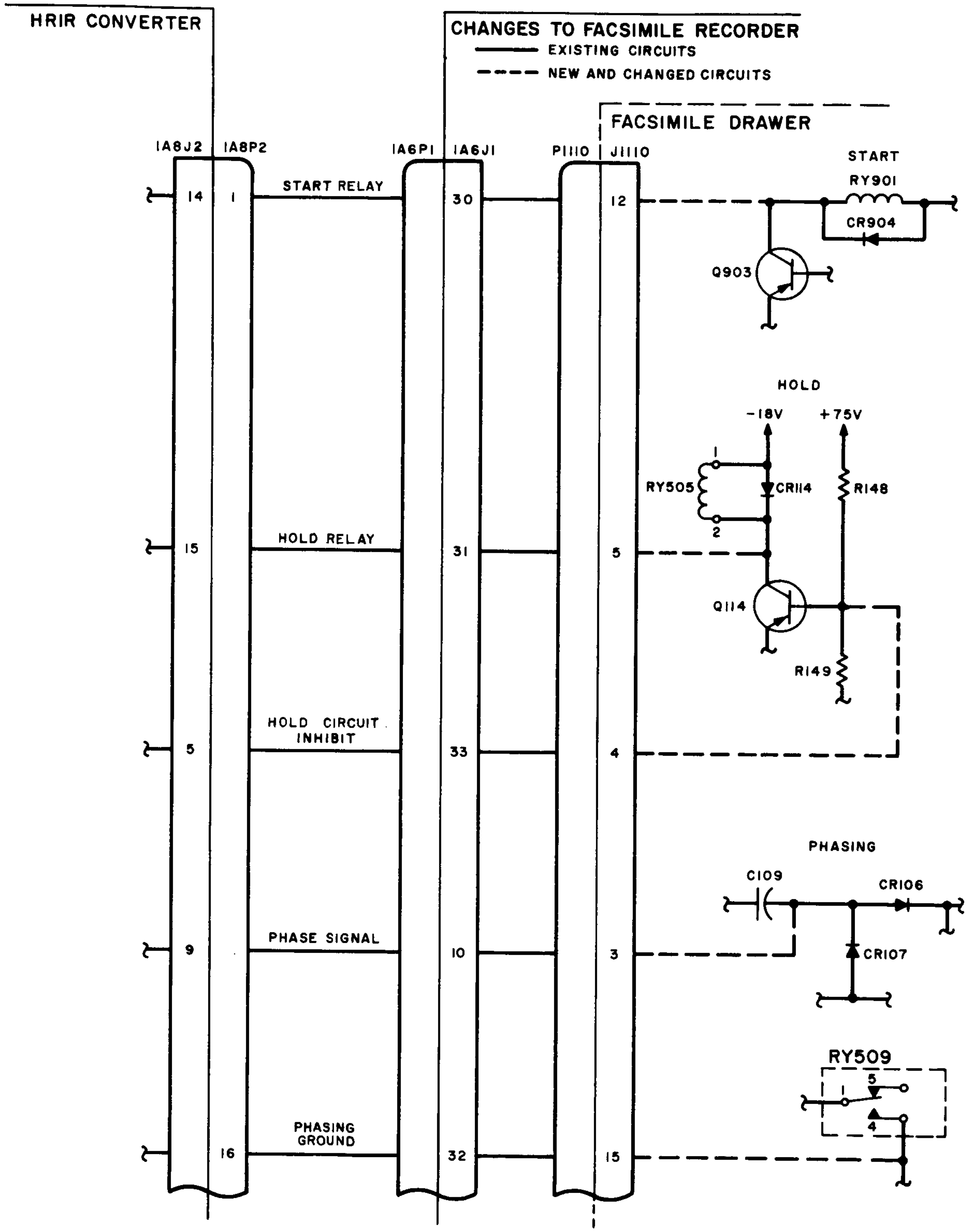


Figure 21. Circuit Modifications for Facsimile Drawer (Sheet 2 of 3)

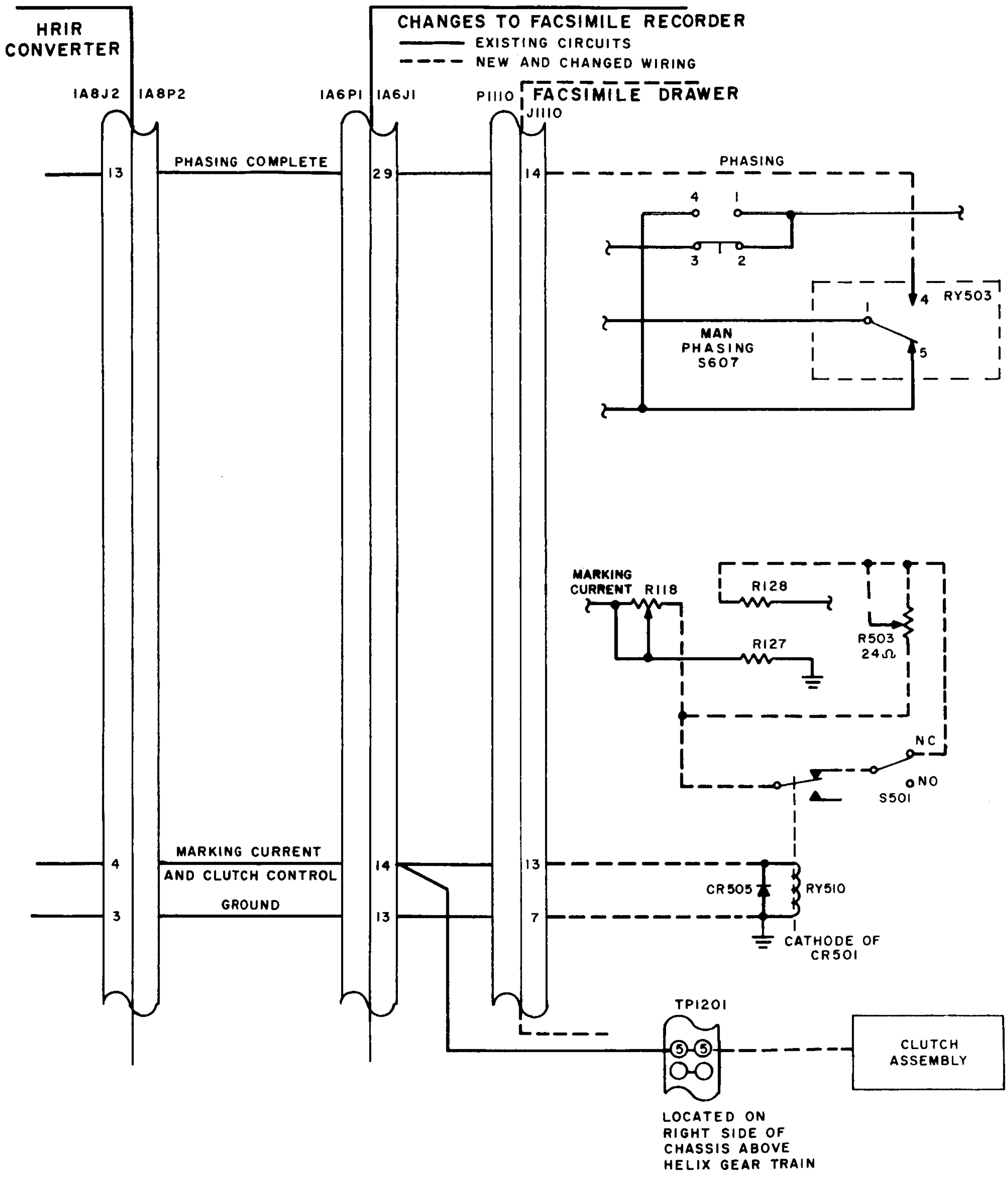
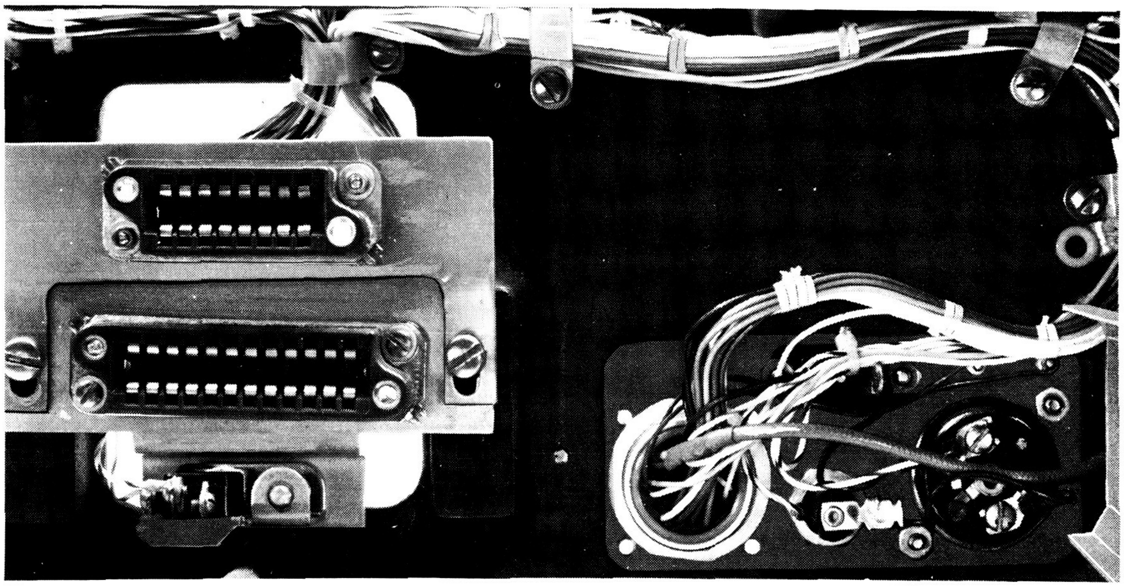


Figure 21. Circuit Modifications for Facsimile Drawer (Sheet 3 of 3)



65-8-88

Figure 22. Chassis Harness Installation

6. Marking Current and Clutch Control, Automatic Mode

The control circuits for the marking current and clutch are similar to the circuit for the manual mode shown in Figure 19, except as follows. A relay, controlled from the HRIR converter, is used instead of a DPDT switch, and a potentiometer is used instead of a fixed resistor. A normally closed switch connected in series with the relay contacts provides the means of adjusting the writing current without energizing the relay. A schematic of the control circuit is shown on sheet 3 of Figure 21. A typical relay and potentiometer installation is shown in Figure 23.

D. ADAPTER HARNESS

The adapter harness provides circuit continuity between the facsimile recorder, the facsimile test set, and the HRIR converter. Electrical connections for the wires between the HRIR converter and the facsimile recorder are shown in Figure 21. Connections between the facsimile test set and the facsimile recorder have not been affected. Outline and assembly information is shown in Figure 49.

E. EXTENDER CABLE

The extender cable is used to connect the facsimile-recorder drawer to the chassis when the drawer is removed for troubleshooting. When used, the extender cable is connected between jack J1110 on the drawer and plug P1110 on the chassis. A complementary cable, furnished as part of the ground station, is connected to jack J1101. Outline and assembly information for the extender cable is shown in Figure 29.

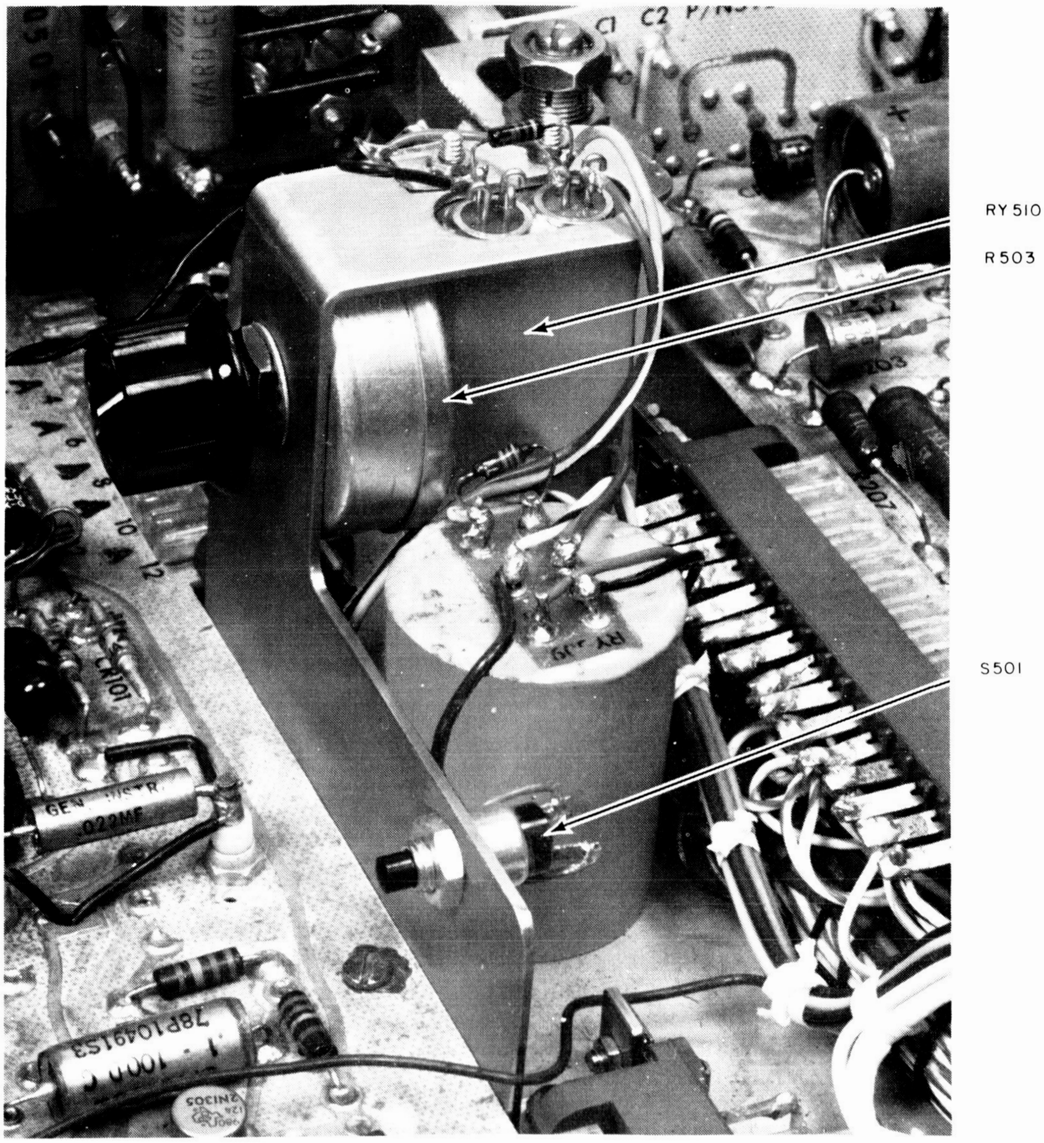
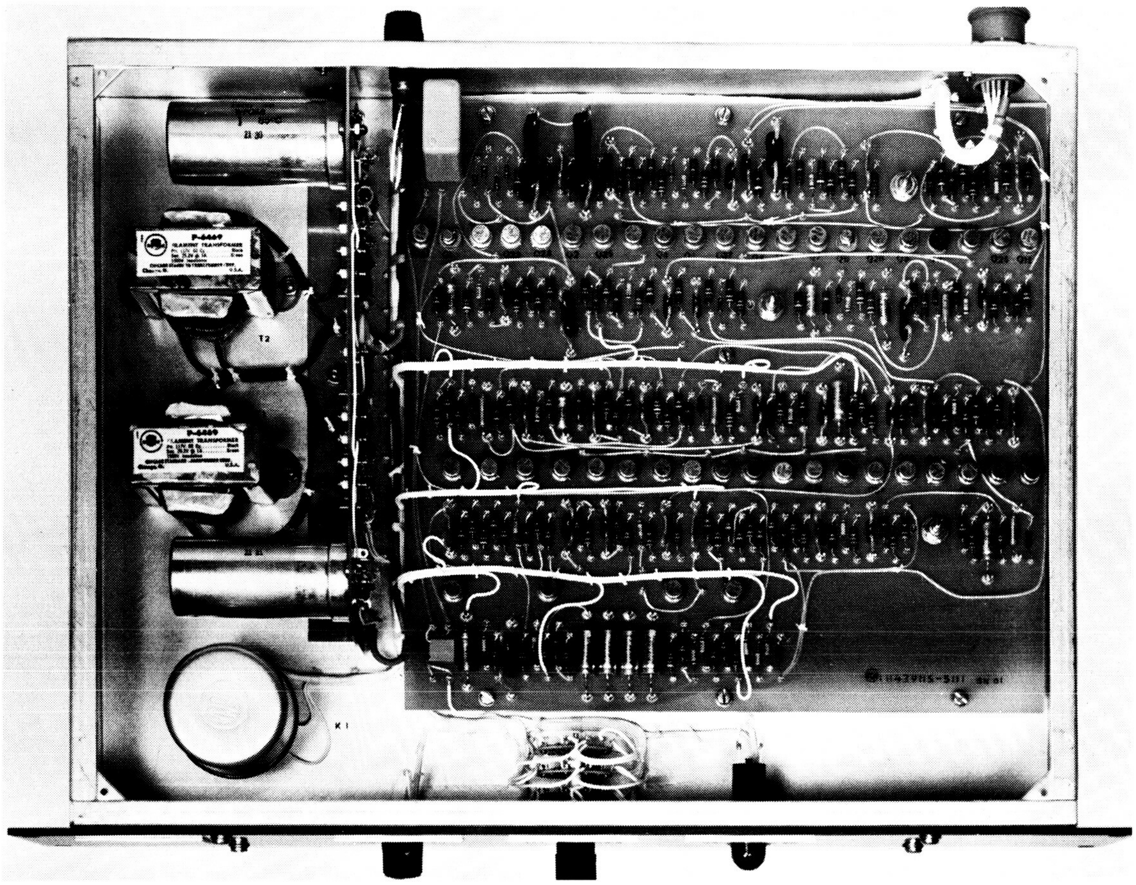


Figure 23. Relay and Potentiometer Installation for Marking Current and Clutch Control

F. HRIR CONVERTER

1. General

The HRIR converter detects the marker pulses from the HRIR signal and generates the control signals necessary for the automatic mode of operation. It consists of a self-contained power supply and electronic circuits as shown in Figure 24. Both a functional and detailed description are provided in the following paragraphs.



65-10-167

Figure 24. HRIR Converter, Internal View

Component layout and assembly details are shown in Figures 50, 52, and 53. A complete chassis schematic is shown in Figure 51.

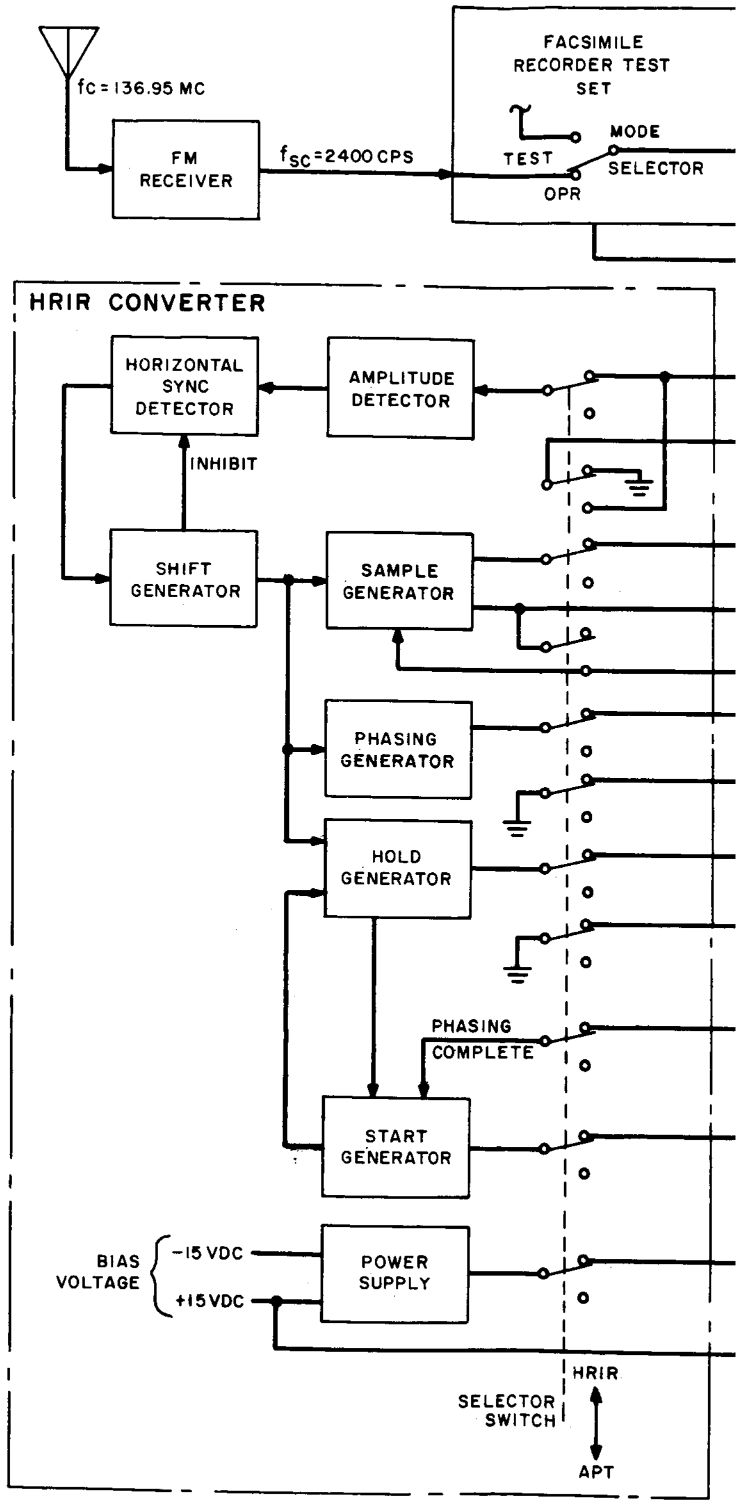
2. Functional Description

The HRIR signal contains video and marked pulses but does not contain the control signals required by the facsimile recorder. During APTS operation two control signals are detected and used to perform these functions; one is a 300-cps start tone that lasts for 3 seconds; the second is a series of phasing pulses that last for 5 seconds and occur at the APTS line rate (4pps). These signals are responsible for starting and executing the phasing cycle (centering), and for providing a reference period during which a motor driven servo adjusts the gain of the facsimile recorder circuits.

During HRIR operation, the control signals are generated by the HRIR converter and supplied to the facsimile recorder. A block diagram in Figure 25 shows the relationship of the HRIR converter and the facsimile recorder. The HRIR timing chart for Nimbus C

(Figure 26) is used to supplement the block diagram and the functional description. When the selector switch is set to APT, power is removed from the HRIR converter circuits to eliminate the possibility of circuit interference during the APTS mode of operation. When the selector switch is set to the HRIR position, power is applied to the HRIR converter and the 2400-cps subcarrier is applied to the existing amplitude detector in the facsimile recorder. The output of the detector supplies the analog signal to the marking circuits where it is used to modulate the writing current. Simultaneously, the 2400-cps subcarrier is applied to the HRIR converter where an identical analog signal is derived from an amplitude detector. The second analog output is then applied to the horizontal sync detector where five of the marker pulses are detected and shaped into a horizontal sync pulse (waveform F on timing chart). The detection of 5 marker pulses reduces the possibility of triggering the control circuits with random noise signals. The sync pulse is applied to the shift generator where two signals are formed. One output signal inhibits the operation of the horizontal sync detector until the earth scan is completed and insures that the video does not trigger the sync circuits. The second output is delayed 530 milliseconds (waveform G on timing chart) to ensure that the start cycle (hold, phasing, and sample generators) is triggered during the space-scan period (120.8 milliseconds) following the earth scan.

The hold generator insures operation of the facsimile recorder until the loss of sync exceeds 8 seconds. The output of the shift generator, 530 + 20 milliseconds long, energizes a relay driver via an OR gate. When the voltage from the shift generator ends (end of the earth scan) a one-shot is triggered. The output of the one-shot provides a signal to the OR gate until a new sync pulse is detected. Thus, a continuous voltage is supplied to the relay driver as long as sync pulses are present. Operation of the relay driver energizes relay RY505 in the facsimile recorder and power is applied to the writing circuits, AGC circuits, and the drive-motor circuits. Simultaneously, a second output of the hold generator (waveform K on timing chart) triggers the start generator that energizes RY901 in the facsimile recorder. Thus, the output of the start generator performs the function performed by the detected 300-cps start tone of the APTS signal. Relay RY901 energizes an 8-second timer that enables the phasing and AGC circuits. During the 8 seconds established by the timer, phasing and AGC must be completed. If horizontal sync is lost before phasing is complete, the hold generator is disabled until the next sync pulse is detected. If the remainder of an 8-second cycle is too short to complete phasing, a second 8-second cycle is started. When phasing is complete, a signal from the facsimile recorder resets the start generator, relay RY901 is deenergized, and operation of the facsimile recorder continues until the HRIR signal is lost. If sync is lost temporarily (less than 7.5 seconds) after phasing is complete, a signal from the start generator drives the hold generator for an additional 8 seconds. This arrangement prevents the start of a new phasing cycle and video dropout if loss of sync is temporary. When sync is lost for more than 8 seconds, the hold circuit is deenergized and the facsimile recorder stops. Recovery of sync, after an 8-second dropout, initiates a new start cycle.


fc = 136.95 MC
FM RECEIVER
f_{SC} = 2400 CPS
FACSIMILE RECORDER TEST SET
TEST
MODE SELECTOR
OPR
HRIR CONVERTER
HORIZONTAL SYNC DETECTOR
AMPLITUDE DETECTOR
INHIBIT
SHIFT GENERATOR
SAMPLE GENERATOR
PHASING GENERATOR
HOLD GENERATOR
PHASING COMPLETE
START GENERATOR
BIAS VOLTAGE
−15 VDC
+15 VDC
POWER SUPPLY
HRIR
SELECTOR SWITCH
APT

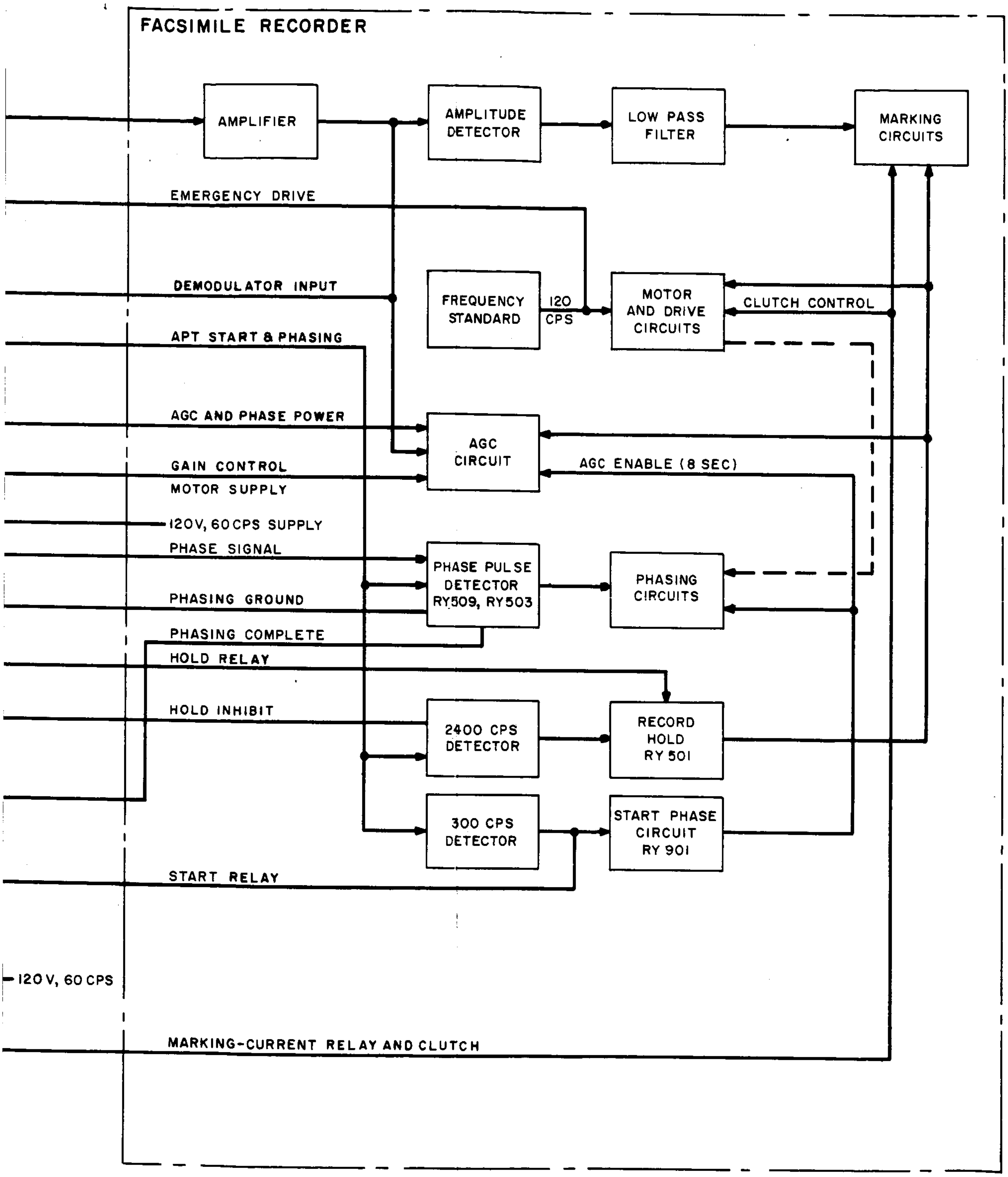


Figure 25. HRIR Functional Block Diagram

Phasing must occur during the 8-second interval established by the start generator. The phasing generator receives the shift generator output and generates simulated phasing pulses for the facsimile recorder (waveform R on timing chart). The position of these pulses, controlled by adjusting the HORIZ POSITION control on the HRIR converter, allows the earth readout to be locked-in at various horizontal positions on the facsimile printout. In the facsimile recorder, the phasing pulses are compared to a signal generated by the cam-operated contacts on the helix shaft. When the two signals are in phase, the speed of the helix returns to normal and the phasing-complete signal is returned to the start generator. The presence of the phasing-complete signal ends the start cycle.

Automatic gain control must be completed during the phasing cycle. When the start generator enables the AGC and phasing circuits for 8 seconds, minus 18 volts dc (AGC and phase power) is applied to the sample generator in the HRIR converter. Simultaneously, the 80-millisecond sample signal (waveform S on timing chart) is generated. These signals energize a sample relay which supplies 120 volts, 60 cps to the AGC motors in the facsimile recorder. When phasing is complete, minus 18 volts is removed from the sample generator and the relay driver is disabled. Limiting relay operation to the phasing cycle is designed to prolong relay life.

3. Detail Theory

A detailed electrical description is provided for the circuits contained in the HRIR converter. The description is supplemented with a block diagram shown in Figure 27 and the timing chart on Figure 26.

a. DEMODULATOR

The amplified-subcarrier input from the facsimile recorder is applied to the demodulator where the signal is detected amd amplified. The demodulated signal is applied to a low pass filter (L1, C2, C3) and then a high frequency compensating network (C4, R3). The filter attenuates the video frequencies (300 cps maximum) and passes the higher frequency marker pulses (1600 cps). The marker pulses (waveform B) are amplified, differentiated, and applied to emitter follower Q3 which prevents loading of the horizontal sync detector. The modulator input and output signals are shown by waveforms A and C.

b. HORIZONTAL SYNC DETECTOR

Marker pulses from emitter follower Q3 are applied to Schmitt trigger Q4, Q5 and inhibit switch Q12. Each marker pulse triggers Schmitt trigger Q4, Q5, that supplies a signal to inhibit one-shot Q13, Q14 and charge one-shot Q6, Q7. The inhibit one-shot output, 10 milliseconds long, drives inhibit switch Q12 which in turn connects the Schmitt trigger input to ground. Operation of the inhibit switch eliminates spurious pulses or noise spikes from triggering the charge one shot for 10 milliseconds between marker pulses.

The charge one-shot, triggered by each detected marker pulse, drives current generator Q8 which in turn provides a constant charge current to capacitor C9 in the counter circuit. Five consecutive pulses from the Schmitt trigger provide the time required to charge capacitor Q9 to the threshold level of unijunction timer Q9. When triggered, the unijunction timer provides a 4-microsecond sync pulse (waveform F) that is amplified and supplied to the shift generator. When activated, the shift generator supplies a signal to the charge one-shot which inhibits further operation for the duration of the earth scan period. If 5 consecutive pulses are not detected the charge one-shot returns to the off condition, the constant current source to capacitor C9 is removed, and the charge in capacitor C9 is dissipated through resistor R20. Consequently, pulses spaced too far apart will not be integrated by the charge capacitor (see waveform E).

c. SHIFT GENERATOR

In the shift generator the horizontal sync pulse sets flip-flop Q25, Q27 (assume that the flip-flop was reset when power was turned on), and the ZERO output is used to inhibit the charge one-shot in the horizontal sync detector. Inhibiting the horizontal sync generator insures that there is no interference during the printout of the video data. Simultaneously, the negative-going ONE output drives amplifier Q29 to cut off, capacitor C29 exceeds the threshold voltage of uninjunction timer Q30, and the output signal resets flip-flop Q27, Q25. The positive-going ONE output triggers the hold, phasing, and sample generators. It is essential that the flip-flop is reset during the 120.8-millisecond space scan; therefore, potentiometer R85 is adjusted until the positive-going ONE output occurs at least 530 milliseconds after the horizontal sync pulse. This insures that the AGC function is performed when a maximum white-level signal is available. The output of the shift generator is shown by waveform G.

d. HOLD GENERATOR

The hold generator amplifies the output of the shift generator and energizes relay driver Q36 through OR gate Q34, Q35. Relay-driver Q36 energizes relay RY505 in the facsimile recorder, and power is applied to the drive motor and writing circuits. Since the output of the shift generator terminates at the end of the earth scan, the following means of maintaining the hold function is used. The turn-off voltage of the shift generator activates hold one-shot Q31, Q32 which delivers a voltage to the OR gate for a time sufficient to reactivate the shift generator. Thus a continuous voltage is supplied to the hold circuit in the facsimile recorder and relay RY505 is energized as long as sync pulses are detected. If sync is lost before phasing is complete the hold generator is disabled when the hold one-shot returns to the stable state. After phasing is complete, the output of inverter Q44 maintains the hold function for 8 seconds if horizontal sync is lost. The output of OR gate Q34, Q35, a negative-going signal, also drives the start generator.

e. START GENERATOR

The output of OR gate Q34, Q35 in the hold generator (waveform K) is inverted by amplifier Q37 and used to set start flip-flop Q38, Q39. It is also applied to AND gate CR21, CR22. The ONE output of the flip-flop energizes relay-driver Q40, Q41, and relay RY901 in the facsimile recorder is energized. The closure of relay RY901 initiates an 8-second cycle during which phasing and AGC occurs. The positive-going ZERO output of start flip-flop, Q38, Q39 is applied to AND gate CR21, CR22. Since both the amplifier and ZERO output are positive, the AND gate is inhibited. If sync is lost before phasing is complete, the start flip-flop is reset by the negative-going output of amplifier Q37 and the flip-flop is ready for the next sync pulse. When phasing is complete, a signal (waveform N) from the facsimile recorder, resets the flip-flop, the relay driver is deenergized, and the AND gate is still inhibited. This circuit condition is maintained as long as sync is present. If sync is lost after phasing is complete, both inputs (waveforms L and M) are negative, AND gate CR21, CR22 conducts, and one-shot Q42, Q43 is triggered. One output (waveform P) holds the flip-flop in the reset position for 7.5 seconds and prevents the flip-flop from being set if loss of sync is temporary (less than 7.5 seconds). A second output from one-shot Q42, Q43 is inverted by amplifier Q44 and applied to the relay driver in the hold generator. This prevents the loss of video for 7.5 seconds when sync is lost. If sync is lost for more than 7.5 seconds, the inhibit on the start flip-flop and the hold-relay driver is removed. The next sync pulse initiates a new hold and start cycle.

f. PHASING GENERATOR

When the shift-generator output goes positive, phase-shift one-shot Q15, Q16 is triggered. The output, controlled by the HORIZ POSITION control (potentiometer R39) triggers phase one-shot Q18, Q19. Control of the phase-shift one-shot allows the earth scan readout to be locked-in at various horizontal positions on the facsimile printout. The 37-microsecond output of the phase one-shot, amplified to the proper levels by driver Q17, is applied to the phase-pulse detector in the facsimile recorder. The phase pulse and the control signal are shown by waveforms R and Q.

g. SAMPLE GENERATOR

When relay RY901 in the facsimile recorder is energized by the start generator, minus 18-volts dc enables amplifier Q23, Q24, for 8 seconds and completes a ground for relay-driver Q22. When the shift-generator output goes positive, sample one-shot Q20, Q21 provides an 80 ± 8-millisecond pulse (waveform S) that drives the relay driver and relay K1 is energized. The closure of relay K1 switches 120-volts, 60-cps to the AGC motors in the facsimile recorder. When the phasing cycle ends, the ground circuit for the relay is opened and power switching ends even though the sample one-shot continues to provide a signal for the duration of the HRIR signal.

h. POWER SUPPLY

The power supply provides power to the converter electronics and the marking-current relay in the facsimile recorder. Power is available when the selector switch is set to HRIR. Switching power on for the HRIR mode eliminates the possibility of interference during APT operation. Input power is stepped down in two transformers, rectified by two full-wave bridge circuits, and filtered. Each filter output (+15 vdc and -15 vdc) is shunted with a Zener diode that conducts when the filter output exceeds 15 volts dc. The unregulated output of the positive bridge is applied to the marker-current relay.

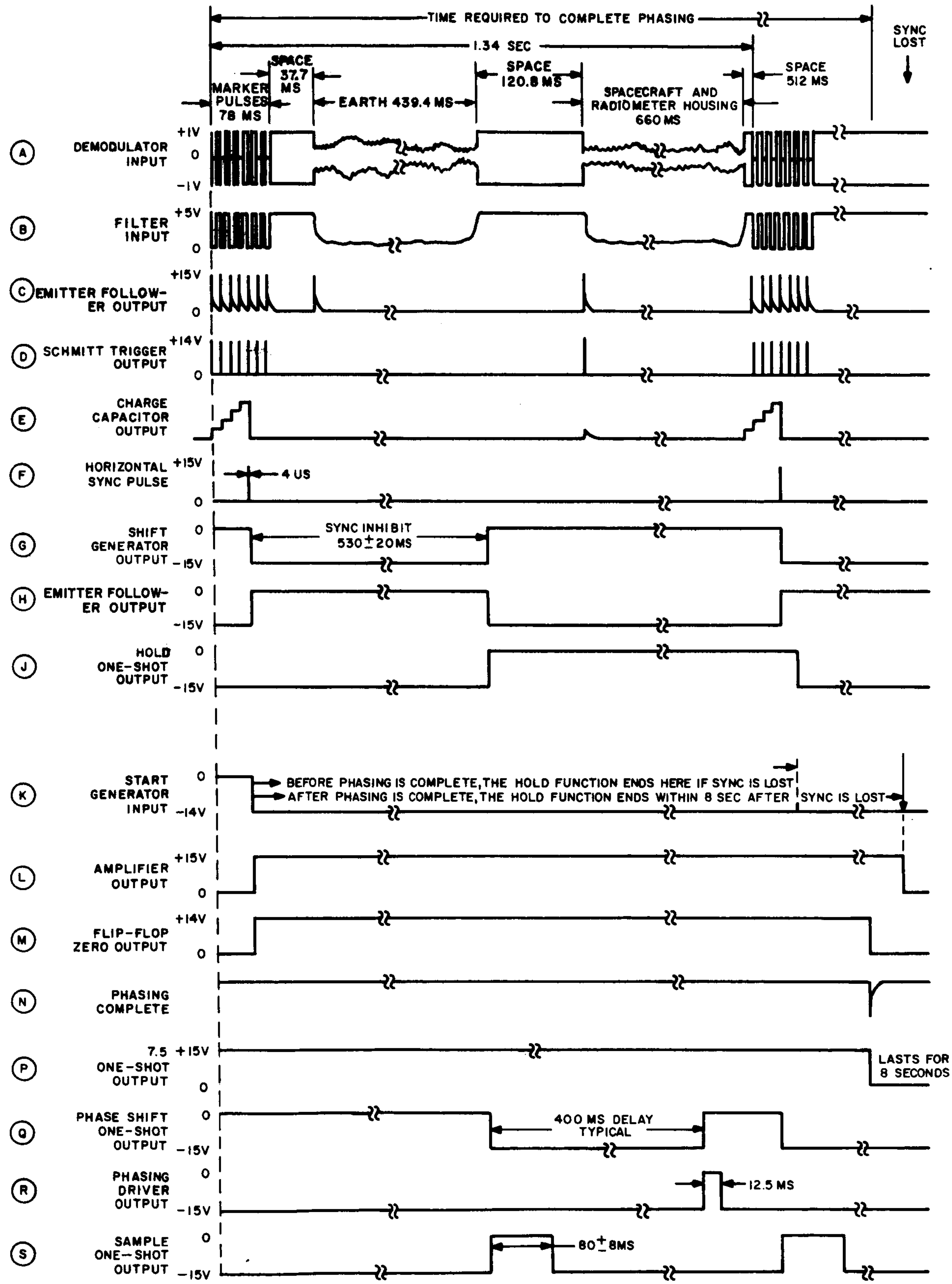
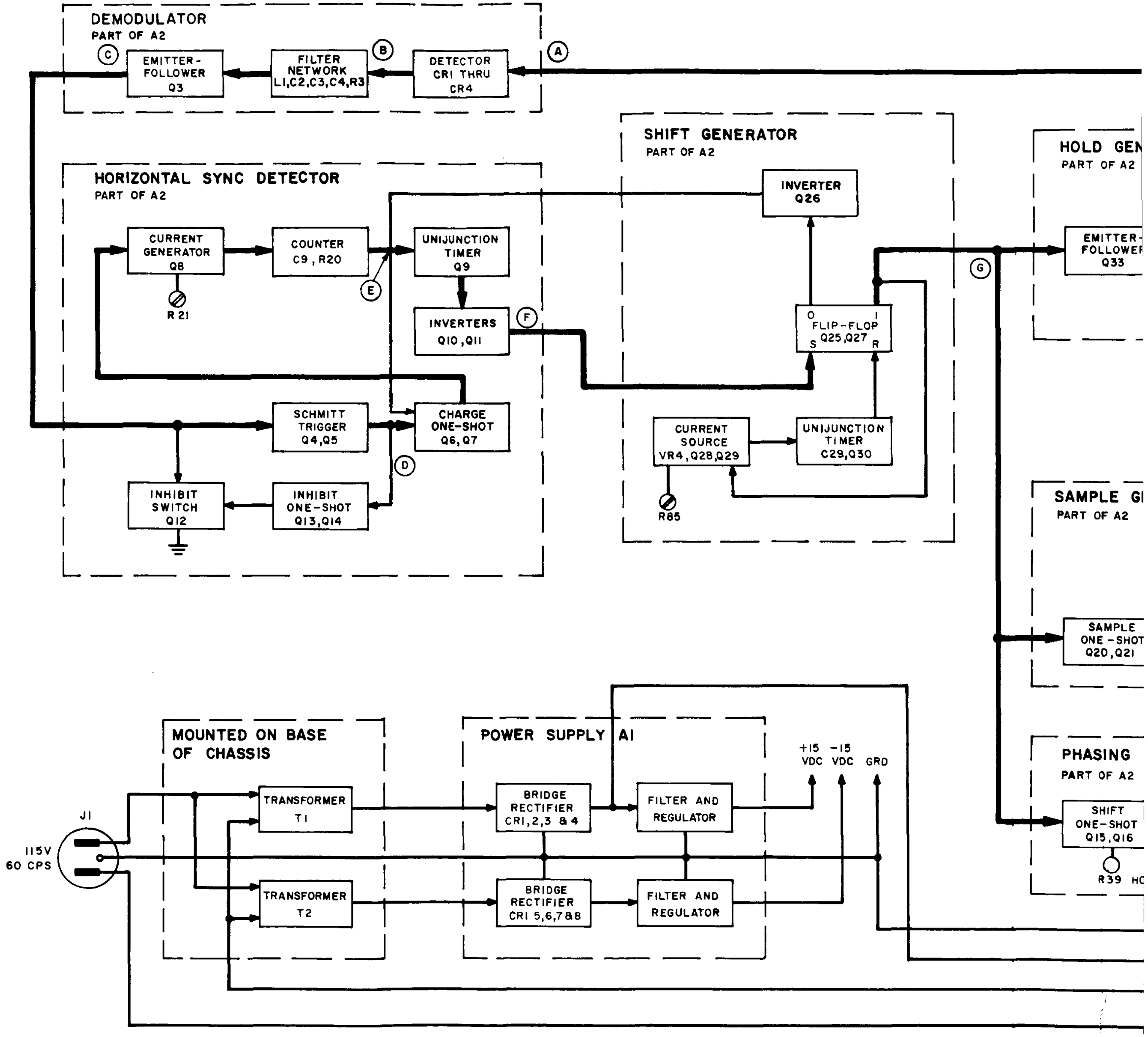
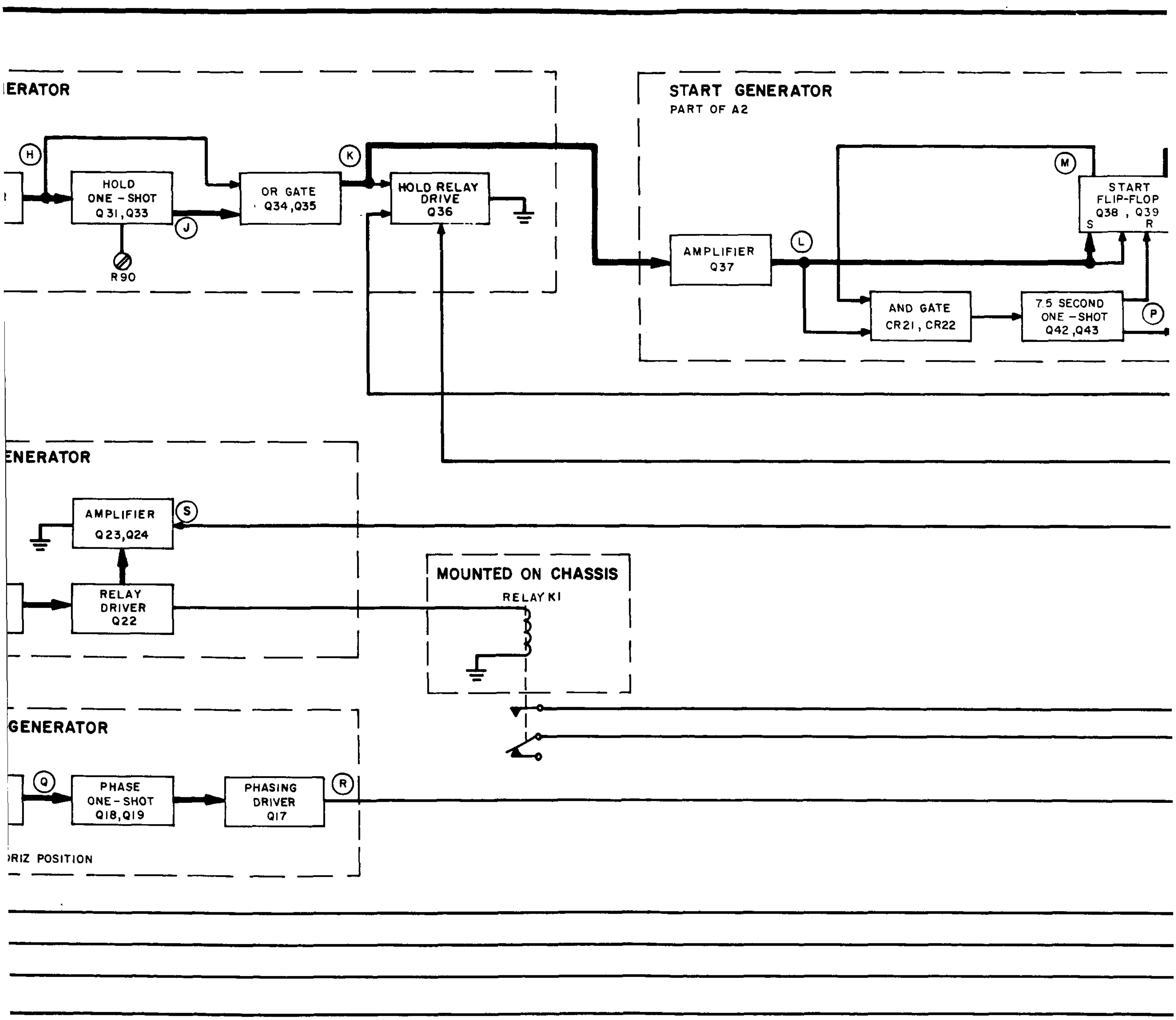


Figure 26. HRIR Converter Timing Chart



DEMODULATOR
PART OF A2
EMITTER-FOLLOWER Q3
FILTER NETWORK L1,C2,C3,C4,R3
DETECTOR CR1 THRU CR4
A
B
C
HORIZONTAL SYNC DETECTOR
PART OF A2
CURRENT GENERATOR Q8
R21
COUNTER C9, R20
UNIJUNCTION TIMER Q9
INVERTERS Q10, Q11
E
F
SCHMITT TRIGGER Q4,Q5
CHARGE ONE-SHOT Q6,Q7
D
INHIBIT SWITCH Q12
INHIBIT ONE-SHOT Q13,Q14
SHIFT GENERATOR
PART OF A2
INVERTER Q26
FLIP-FLOP Q25,Q27
O
I
S
R
CURRENT SOURCE VR4,Q28,Q29
R85
UNIJUNCTION TIMER C29,Q30
G
HOLD GEN
PART OF A2
EMITTER-FOLLOWER Q33
SAMPLE G
PART OF A2
SAMPLE ONE-SHOT Q20,Q21
PHASING
PART OF A2
SHIFT ONE-SHOT Q15,Q16
R39 HO
MOUNTED ON BASE OF CHASSIS
J1
115V 60 CPS
TRANSFORMER T1
TRANSFORMER T2
POWER SUPPLY A1
BRIDGE RECTIFIER CR1,2,3 & 4
BRIDGE RECTIFIER CR1 5,6,7&8
FILTER AND REGULATOR
FILTER AND REGULATOR
+15 VDC
-15 VDC
GRD


ERATOR
HOLD ONE-SHOT Q31,Q33
R90
OR GATE Q34,Q35
HOLD RELAY DRIVE Q36
START GENERATOR
PART OF A2
AMPLIFIER Q37
START FLIP-FLOP Q38, Q39
S
R
AND GATE CR21, CR22
7.5 SECOND ONE-SHOT Q42,Q43
H
J
K
L
M
P
ENERATOR
AMPLIFIER Q23,Q24
S
RELAY DRIVER Q22
MOUNTED ON CHASSIS
RELAY K1
GENERATOR
Q
PHASE ONE-SHOT Q18,Q19
PHASING DRIVER Q17
R
RIZ POSITION

2

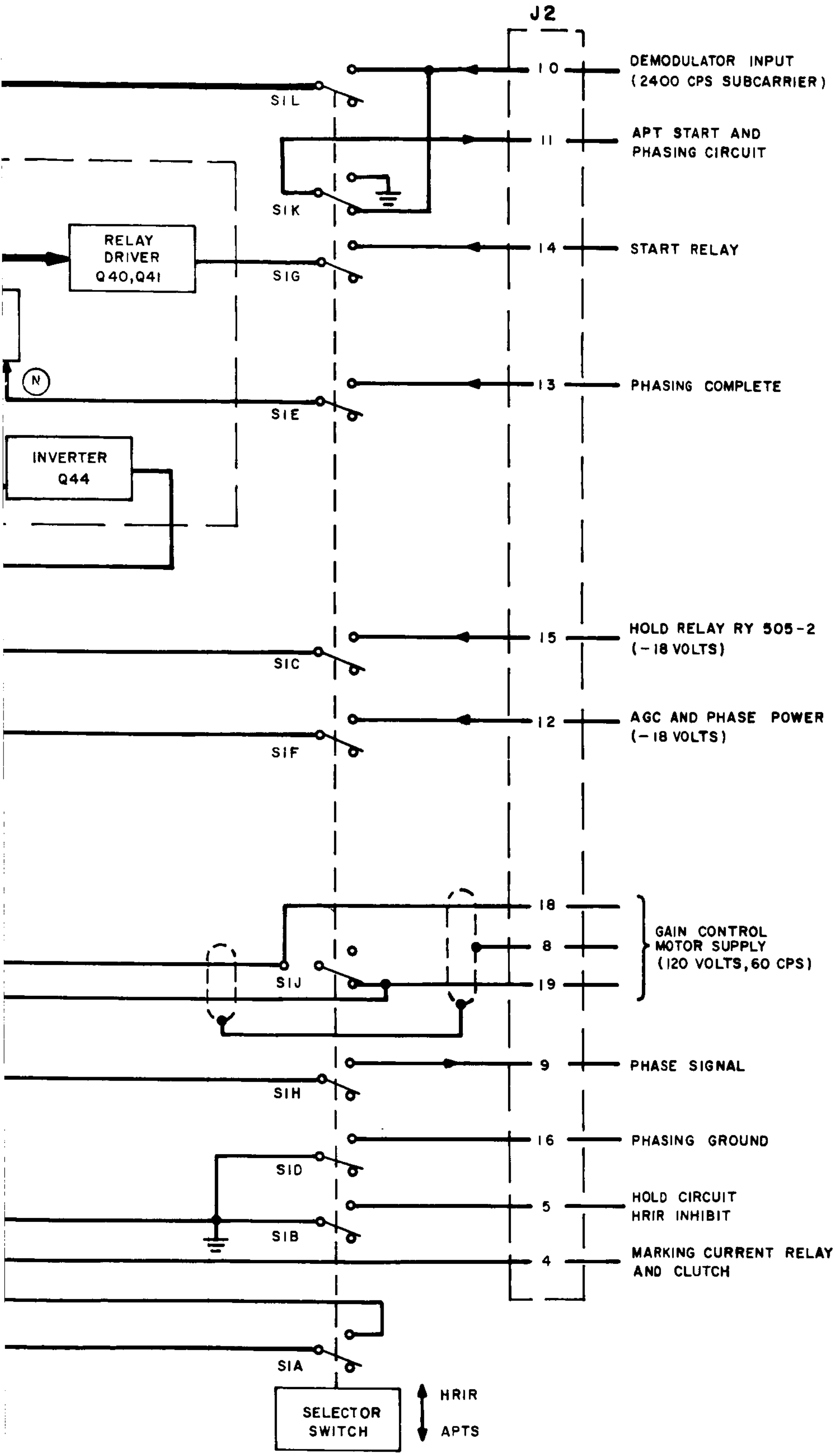


Figure 27. HRIR Converter Block Diagram

SECTION IV

PROCUREMENT DATA

A modification kit (RCA Part No. 1848093) for the Fairchild APTS Ground Stations is commercially available from the Radio Corporation of America. Included in the modification kit are installation, operation, and maintenance instructions. For information pertaining to the procurement of the modification kit, contact the

Marketing Department
Radio Corporation of America
Astro Electronics Division
Defense Electronic Products
Princeton, New Jersey

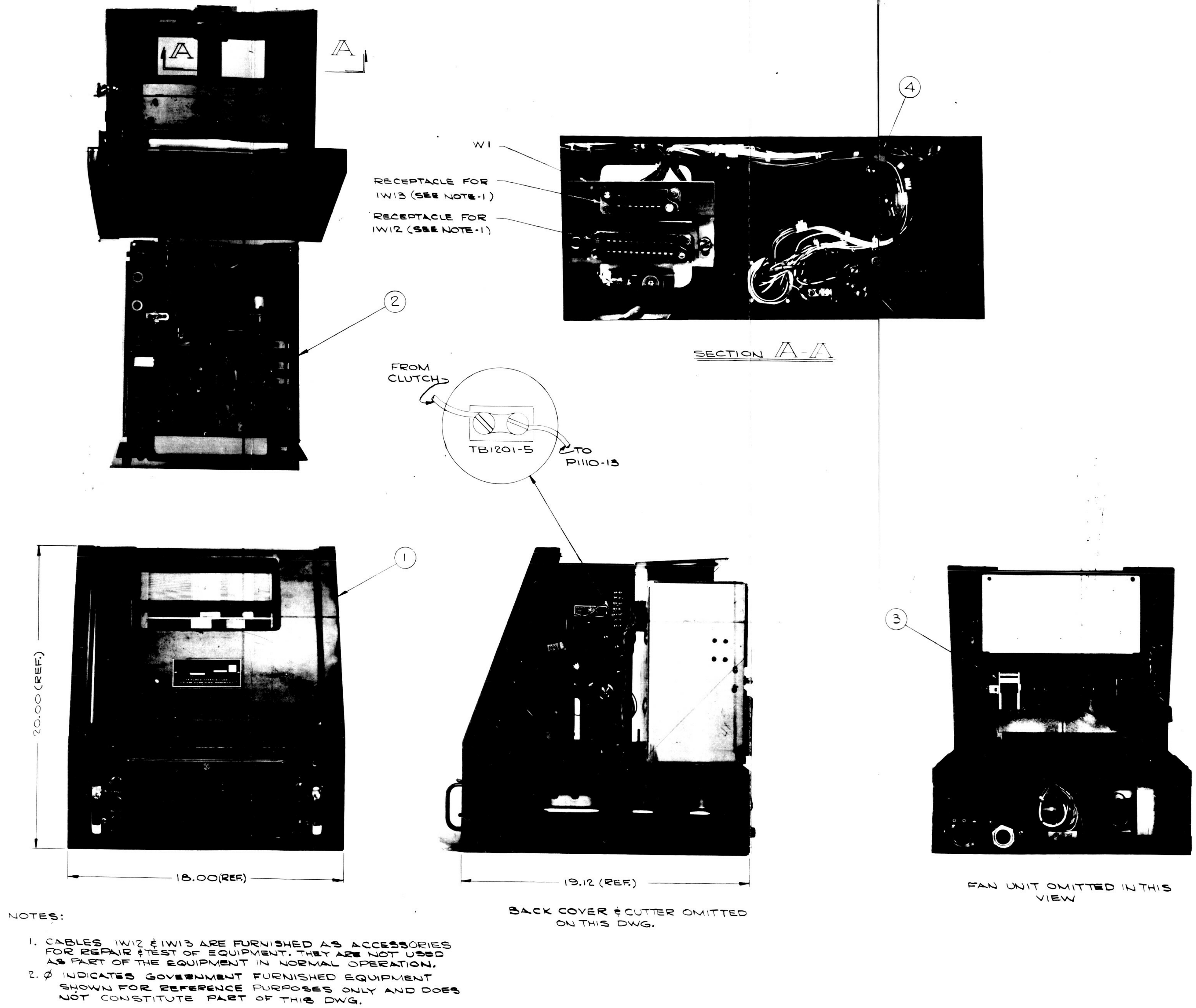
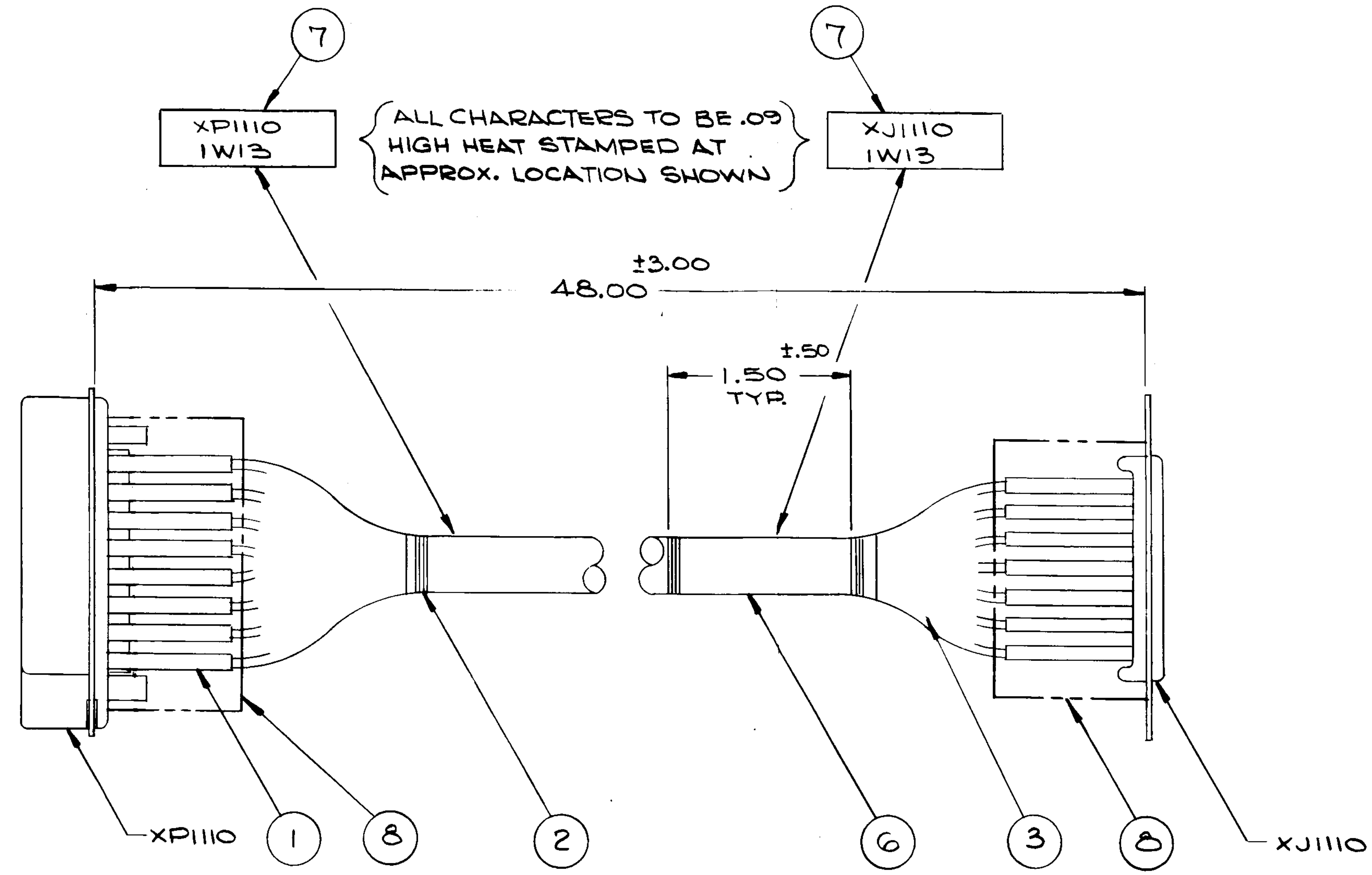
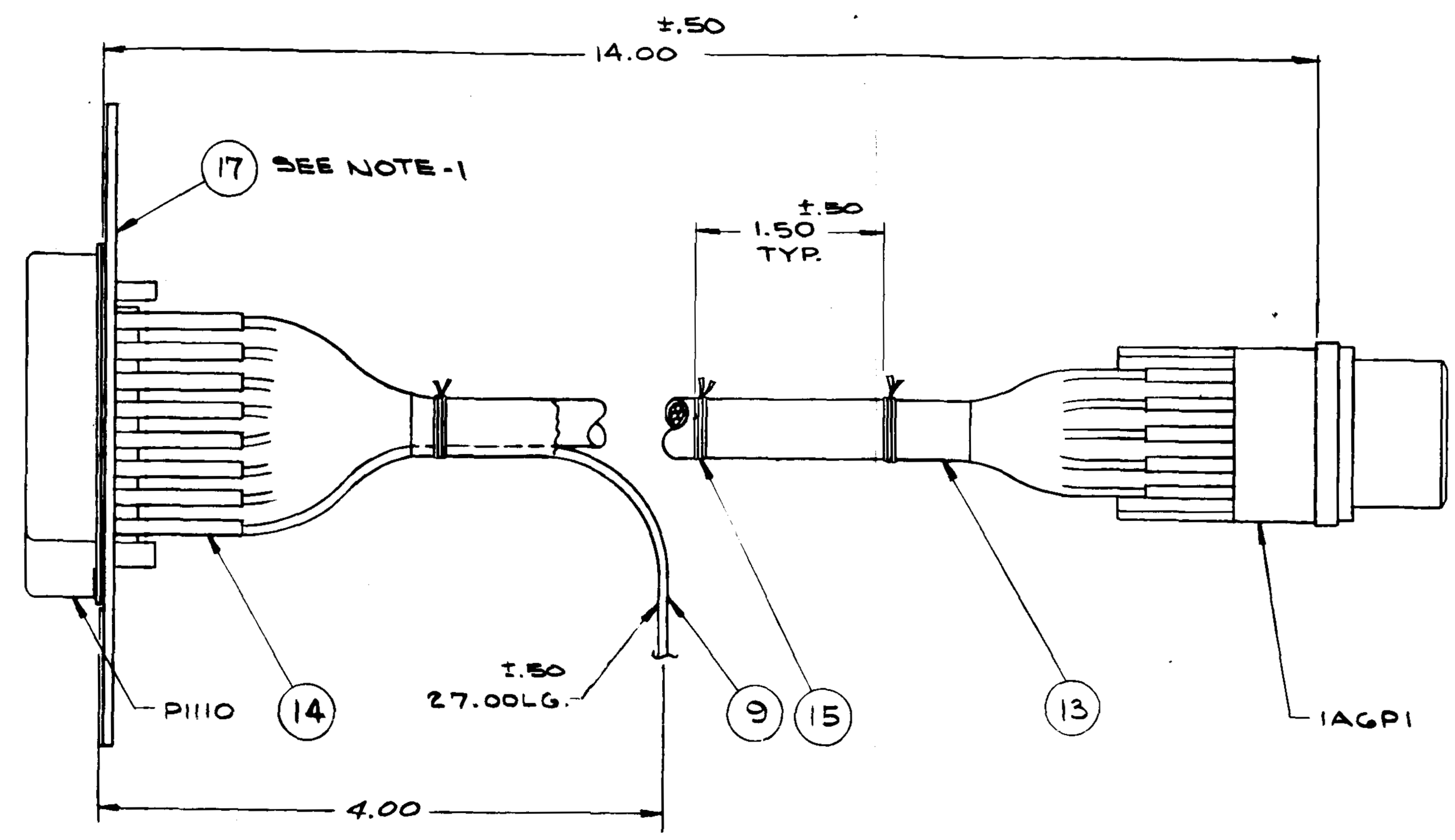


Figure 28. Facsimile Recorder Assembly RCA Dwg 1843778, Rev A



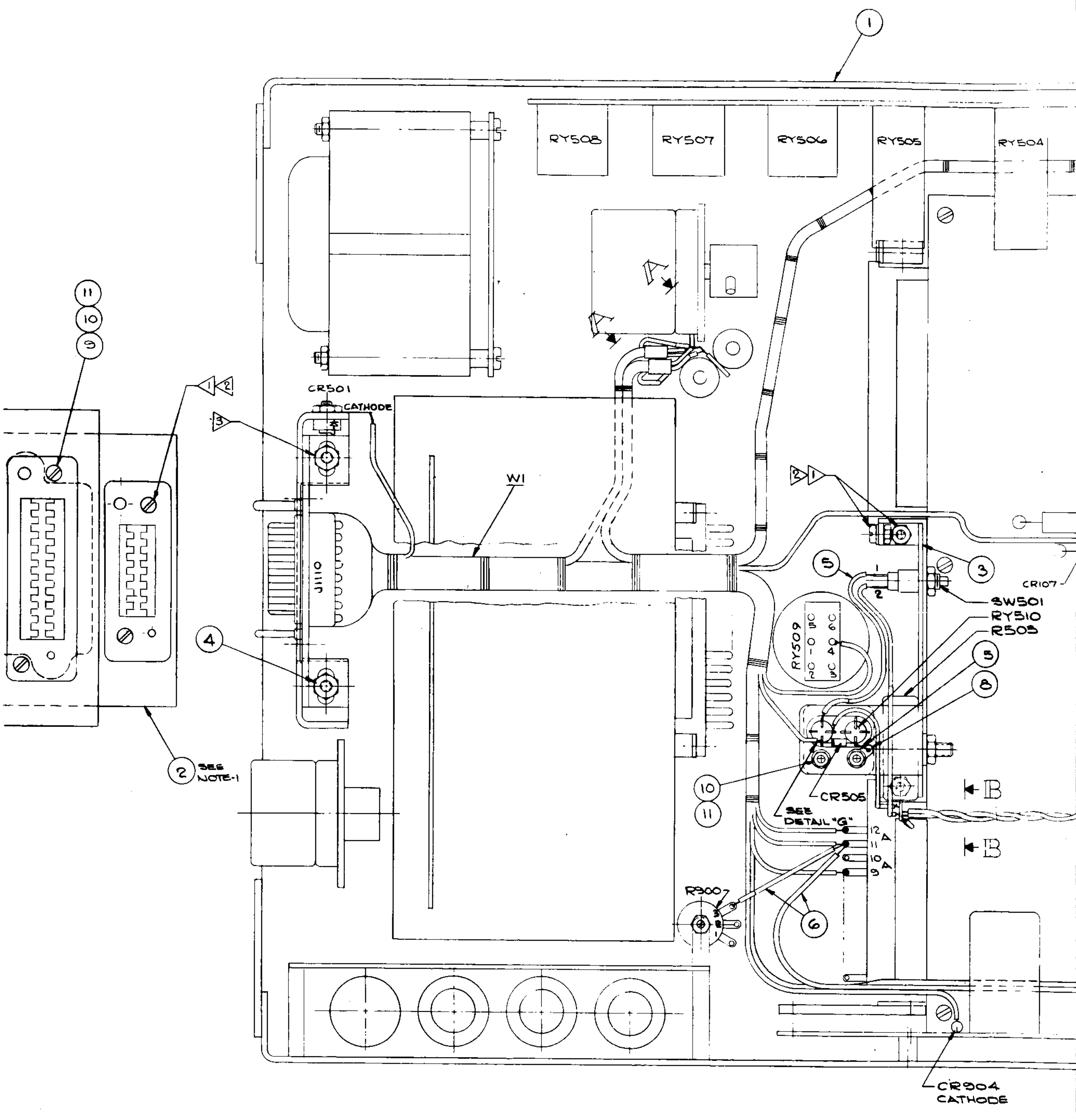
ITEM NO.	TO	FROM
3	XP1110-8	XJ1110-8
3	XP1110-3	XJ1110-3
3	XP1110-4	XJ1110-4
3	XP1110-5	XJ1110-5
3	XP1110-6	XJ1110-6
3	XP1110-7	XJ1110-7
5 (WHT.)	XP1110-1	XJ1110-1
5 (BLK.)	XP1110-9	XJ1110-9
5 (SHD.)	XP1110-10	XJ1110-10
3	XP1110-12	XJ1110-12
3	XP1110-13	XJ1110-13
3	XP1110-14	XJ1110-14
3	XP1110-15	XJ1110-15
3	XP1110-16	XJ1110-16

Figure 29. Extender Cable 1W13,
RCA Dwg 1848252 Rev A



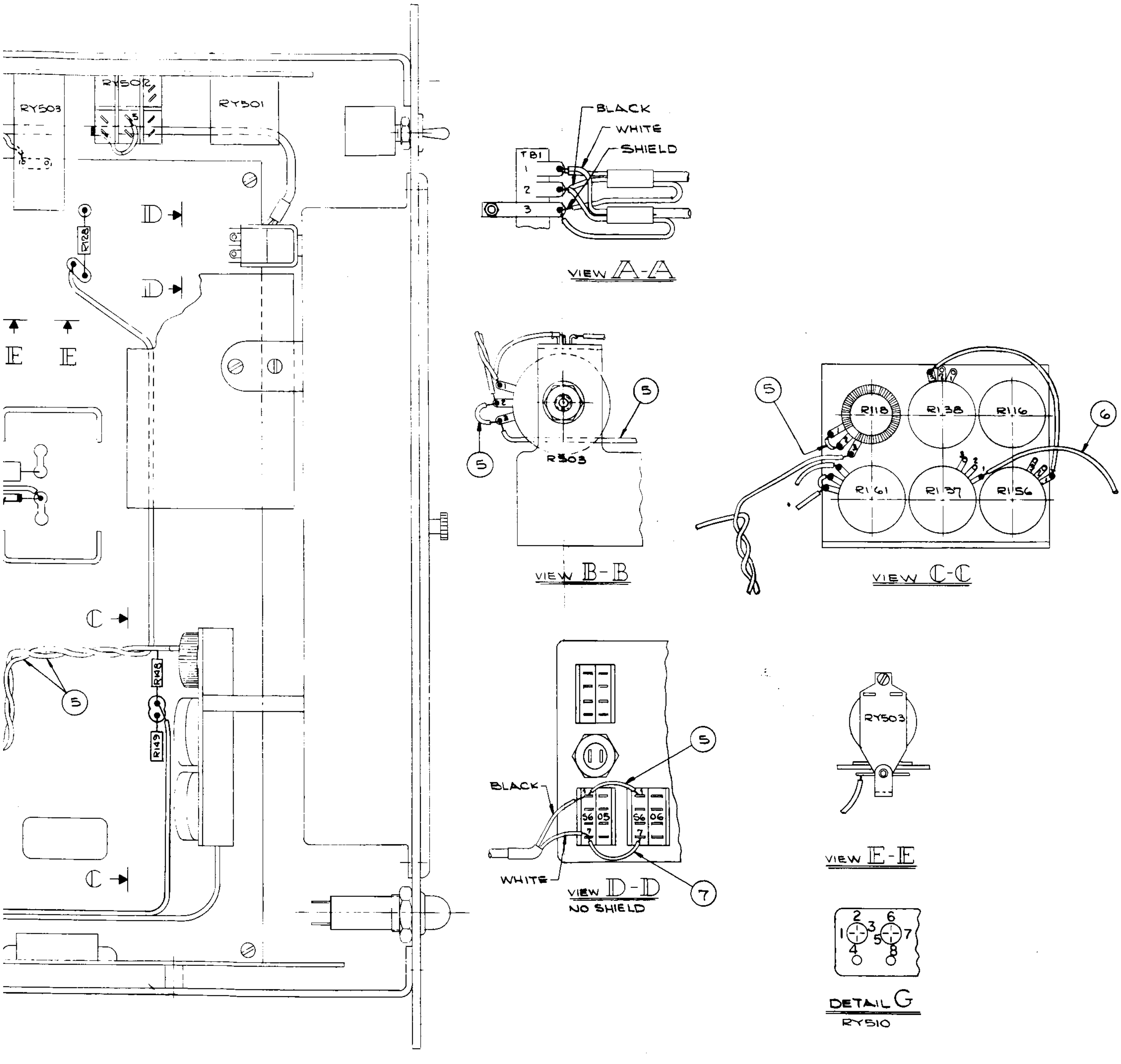
CONNECTION LIST			
ITEM NO.	FROM	TO	TO
7	P1110-8	1A6P1-3	—
2	P1110-3	1A6P1-10	—
3	P1110-4	1A6P1-33	—
4	P1110-5	1A6P1-31	—
5	P1110-6	1A6P1-28	—
6	P1110-7	1A6P1-13	—
1 (WHT.)	P1110-1	1A6P1-34	—
1 (BLK.)	P1110-9	1A6P1-35	—
1 (SHLD.)	P1110-10	1A6P1-18	—
8	P1110-12	1A6P1-30	—
9	P1110-13	1A6P1-14	—
10	P1110-14	1A6P1-29	—
11	P1110-15	1A6P1-32	—
12	P1110-16	1A6P1-4	—
9	P1110-13	—	TB1201-5

Figure 30. Harness Assembly Chassis
RCA Dwg 1848265 Rev B



CONNECTION LIST			
ITEM	FROM	TO	LGN. IN. IN.
6	A11	R300-3	3.00
6	A11	R137-1	14.00
5	RY510-2	SW501-1	6.00
5	RY510-3	R503-1	2.00
5	RY510-8	ITEM-8	1.00
5	R503-3	SW501-2	7.00
5	R503-3	R503-2	1.00
5	R503-2	R118-3	7.00
5	R503-1	R128	14.00
—	CR505-C	RY510-4	—
—	CR505-A	RY510-8	—
5	S605-1	S606-1	1.00
7	S605-7	S606-7	1.00
5	R156-1	R138-3	3.00

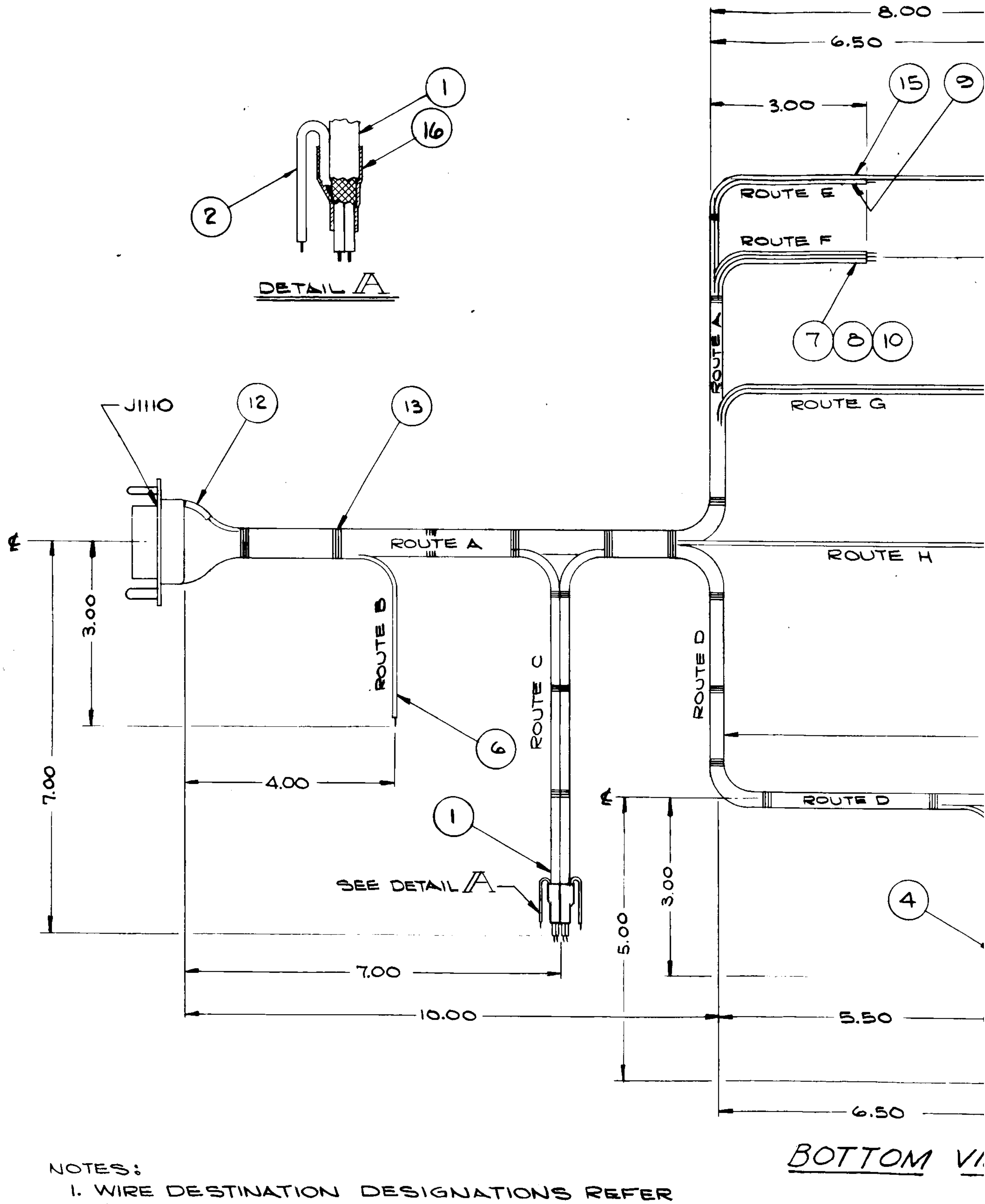
	LIST OF PAR	
	QTY.	D
1	6	NU
2	6	SC
3	2	NU



TS SALVAGED
ESCRIPTION
,HEX #4-40
REW, PAN HD.#4-40
T, HEX # 8-32

LIST OF PARTS DELETED	
QTY.	DESCRIPTION
2	SCREW, PAN HD. #8-32
1	WIRE, FROM R118-3 TO R128, RED/WHITE
1	WIRE, FROM R137-1 TO R138-3, BLACK
1	WIRE, FROM R137-1 TO R156-1, BLACK
2	BRACKET, ANGLE

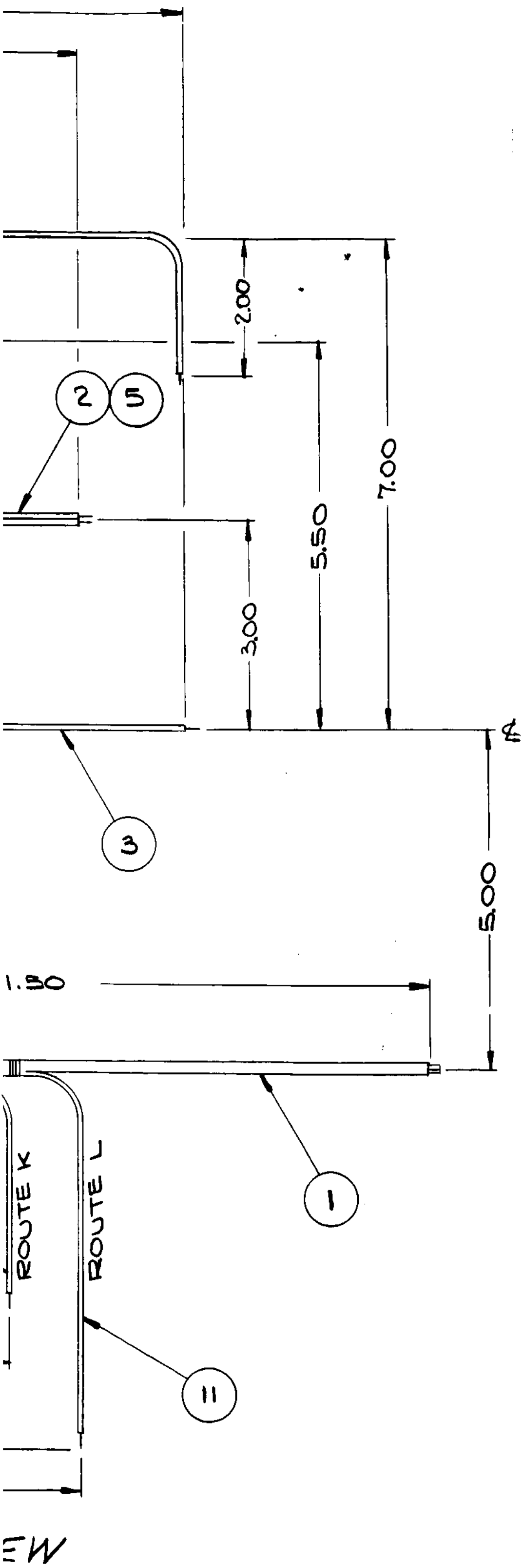
Figure 31. Installation and Harness Assembly, RCA Dwg 1843736 Rev A



BOTTOM VI

NOTES:

1. WIRE DESTINATION DESIGNATIONS REFER TO DESIGNATIONS SHOWN ON INSTALLATION DWG. 1843736.



CONNECTION LIST				
ITEM	FROM	ROUTE	LGN. IN IN.	TO (SEE NOTE-1)
8	J1110-8	AF	18.50	A12
3	J1110-3	AH	18.00	CR107-CATH.
15	J1110-4	AE	27.00	R148 & R149
7	J1110-5	AF	18.50	A9
11	J1110-6	ADL	26 50	RY502-5
6	J1110-7	AB	7.00	CR501-CATH.
1(WHT.)	J1110-1	AC	14.00	TB1-1
1(BLK.)	J1110-9	AC	14.00	TB1-2
1(SHLD)	J1110-10	AC	14.00	TB1-3
9	J1110-12	AE	20.00	CR504-CATH.
5	J1110-13	AG	19.50	RY510-4
4	J1110-14	ADK	23.50	RY503-4
2	J1110-15	AG	19.50	RY509-4
10	J1110-16	AF	18.50	A11
1(WHT.)	TB1-1	CAD	26.50	S605-7
1(BLK.)	TB1-2	CAD	26.50	S605-1
1(SHLD)	TB1-3	CAD	26.50	TERMINATE

Figure 32. Harness Assembly, Drawer
RCA Dwg 1848261 Rev A

504	503	502	501	ITEM NO.	LIST OF MATERIALS		
QTY REQD	QTY REQD	QTY REQD	QTY REQD		CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
			1	B1		CC8-1	CLUTCH, DUPLEX (GUIDANCE CONTROL CORP.)
			1	B2		1848220-1	MOTOR
			1	E1		EFT-1	TERMINAL BLOCK (CURTIS DEVELOPMENT)
			1	E2		8868371-11	TERMINAL SPADE LUG
			1	1			BEARING PLATE
			1	2			BEARING PLATE
			1	3		A2-30	SHAFT (PIC DESIGN CORP.)
			1	4		G48S22P2Z7	SPUR GEAR, 22 TEETH (FAIRCHILD)
			1	5			SPACER
			4	6		SFR166SSWG2	BALL BEARING FLANGE (BARDEN CORP)
			2	7			SPACER
			1	8			SPACER
			1	9			GEAR HOUSING
			2	10		G48A34P2Y7	SPUR GEAR 34 TEETH (FAIRCHILD)
			1	11			SHAFT
			2	12			SPACER
			1	13			BASE PLATE
			1	14		G48S72P2Z7	SPUR GEAR 72 TEETH (FAIRCHILD)
			2	15		SR166SSW3-G-2	BALL BEARING (BARDEN CORP.)
			1	16			MOUNTING BRACKET
			1	17			SPUR GEAR 41 TEETH
			2	18			STAND-OFF
			2	19			BEARING RETAINER
			1	20			SPACER
			2	21			BRACKET
			1	22			ADAPTER
			1	23			SHAFT
			1	24			SPUR GEAR 25 TEETH
			1	25			BEARING RETAINER
			3	26		C18	MOUNTING CLAMP (STERLING INSTRU)
			1	27			SHAFT
			1	28		S38SSG2	BALL BEARING (BARDEN CORP.)
			2	29		Z2-2	RETAINER RING (PIC DESIGN CORP.)
			2	30		B6-8	SPACER (PIC DESIGN CORP.)
			AR	31		B6-1	SPACER SHIM (PIC DESIGN CORP.)
			AR	32		B1-1	SPACER SHIM (PIC DESIGN CORP.)
			7	33		MS16995-10	SCREW, SOCKET HD #4-40 .375 LG.
			3	34		NAS1352C02-2	SCREW, SOCKET HD #2-56 .125 LG.
			7	35		MS16995-2	SCREW, SOCKET HD #2-56 .250 LG.
				36		MS16556-604	PIN, DOWEL (.001 OVERSIZE) .062 DIA .375 LG.

✱ VENDOR ITEM—SEE SOURCE CONTROL OR SPECIFICATION CONTROL DRAWING

SYM
B

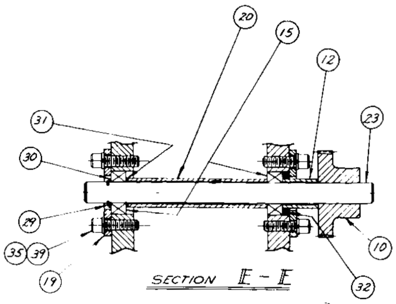
Figure 33. Reduction Gear Assembly RCA Dwg 1723737 Rev B (Sheet 1 of 3)

504	503	502	501	ITEM NO.	LIST OF MATERIALS		
QTY REQD	QTY REQD	QTY REQD	QTY REQD		CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
				37		MS16556-618	PIN, DOWEL (.001 OVERSIZE) .093 DIA. .375LG
			1	38		AN565A2H2	SET SCREW #2-56 .125 LG.
			10	39		NAS1640-2	WASHER LOCK #2
			7	40		NAS1640-4	WASHER LOCK #4
			5	41		NAS1640-6	WASHER LOCK #6
			10	42		NAS1640-8	WASHER LOCK #8
			10	43		MS16995-25	SCREW, SOCKET HD. #8-32 .375 LG.
			4	44		MS16995-18	SCREW, SOCKET HD. #6-32 .500 LG.
			3	45		MS16995-19	SCREW, SOCKET HD. #6-32 .625 LG.
			1	46		NAS1635-06-4	SCREW, PAN HD. #6-32 .250 LG.
			2	47		NAS1635-06-6	SCREW, PAN HD. #6-32 .375 LG.
			1	48		1721122-120	NAMEPLATE
			AR	49		999128-9	WIRE, AWG #22 (WHITE) 7 STRAND
			AR	50		2010164-1	SOLDER 60/40
			4	51		MS15795-304	WASHER, FLAT #4
			AR	52		99123-11	GREASE
				53			TAPER PIN 8/0 X .312 LG. COMMERCIAL 18-8
			X	54		8524919	SPECIFICATION, WORKMANSHIP
			1	55		1847857-1	TAB, NYLON
			1	56		NAS1407N1M8	PIN, SPIRAL .031 DIA X .500 LG
			1	57		392-2170	GEAR, HELICAL (FAIRCHILD)
			X	58		1840901	PROCEDURE, ASSEMBLY
			4	59		MS15795-306	FLAT WASHER #6
			8	60		MS15795-307	FLAT WASHER #8
			4	61		MS15795-309	FLAT WASHER #10
			4	62		NAS1640-10	LOCK WASHER #10
			4	63		MS16996-10	SCREWS, SOCKET HEAD
			AR	64		8954869-27	COMPOUND, STAKING
			AR	65		#400	*SCOTCH TAPE (DOUBLE FACE) 3M COMPANY

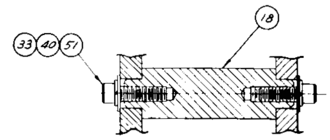
* VENDOR ITEM—SEE SOURCE CONTROL OR SPECIFICATION CONTROL DRAWING

SYM
B

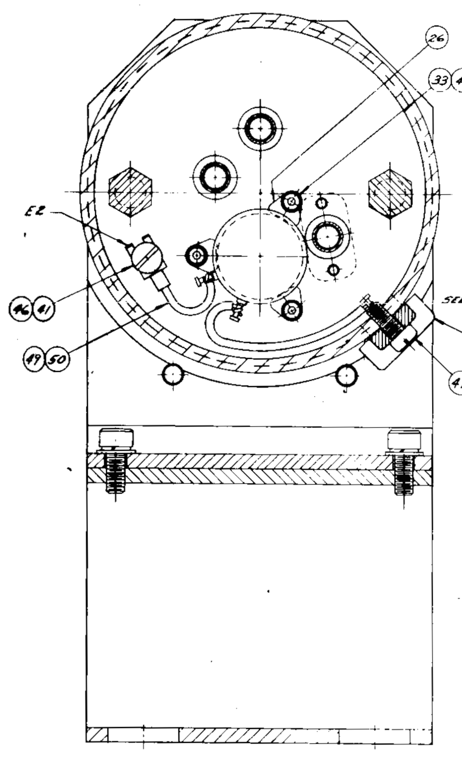
Figure 33. Reduction Gear Assembly RCA Dwg 1723737 Rev B (Sheet 2 of 3)



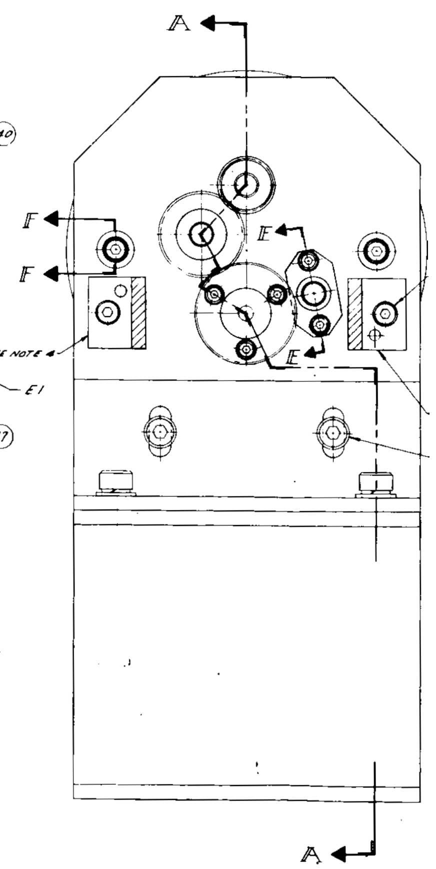
SECTION E - E



SECTION F - F



SECTION C - C



SECTION B - B

NOTES:
1. BEARINGS ARE TO BE SHIMMED BETWEEN SPACERS, ITEMS 7 & 20 AND BEARINGS ITEMS 6 & 21 TO GUARANTEE A PRELOAD OF .002 (APPROX. 9 SHIMS REQUIRED, ITEM 31, PER SHAFT).
2. LUBRICATE ALL GEAR TEETH WITH GREASE, ITEM 52.
3. ITEMS 1 & 2 ARE MATCHED PAIRS AND ARE NOT TO BE INTERCHANGED.
4. BEARING ITEM 28, SHAFT ITEM 27 AND BEARING RETAINER ITEM 25 ARE TO BE ALIGNED WITH CLUTCH ITEM 41 TO HAVE A MAX. SHAFT RUN-OUT OF .001 T.I.R.
5. FOR ASSEMBLY SEE RCA DWG 1840901
6. APPLY LOCKTITE (RCA #8954869-27) TO ALL SCREWS THAT DO NOT HAVE LOCKWASHERS

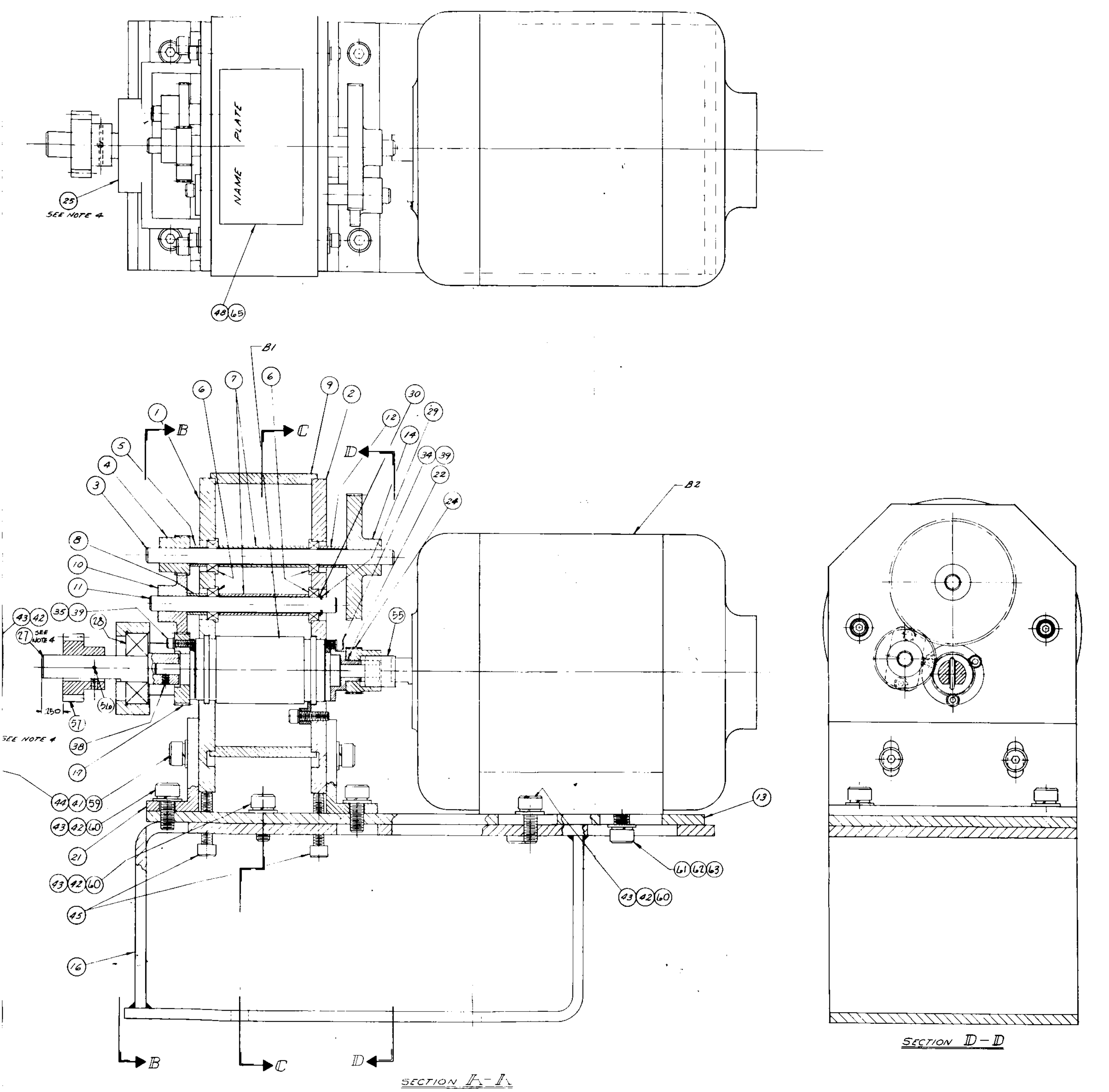
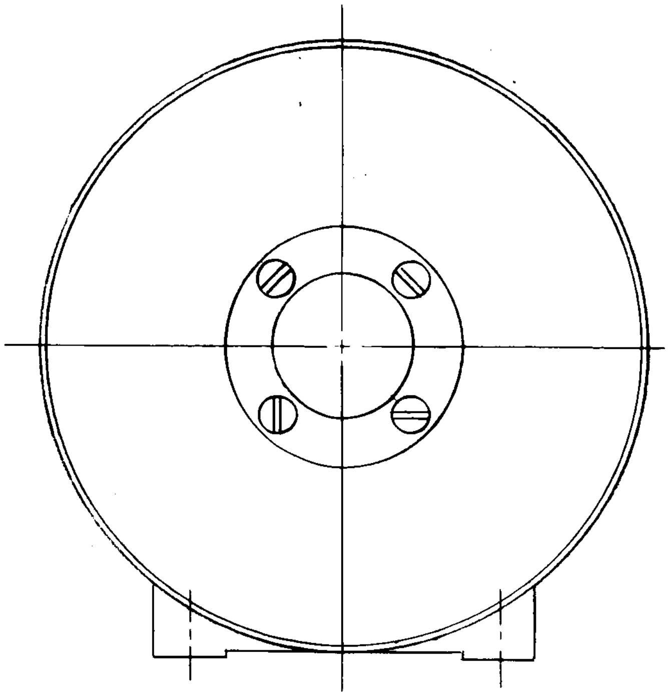


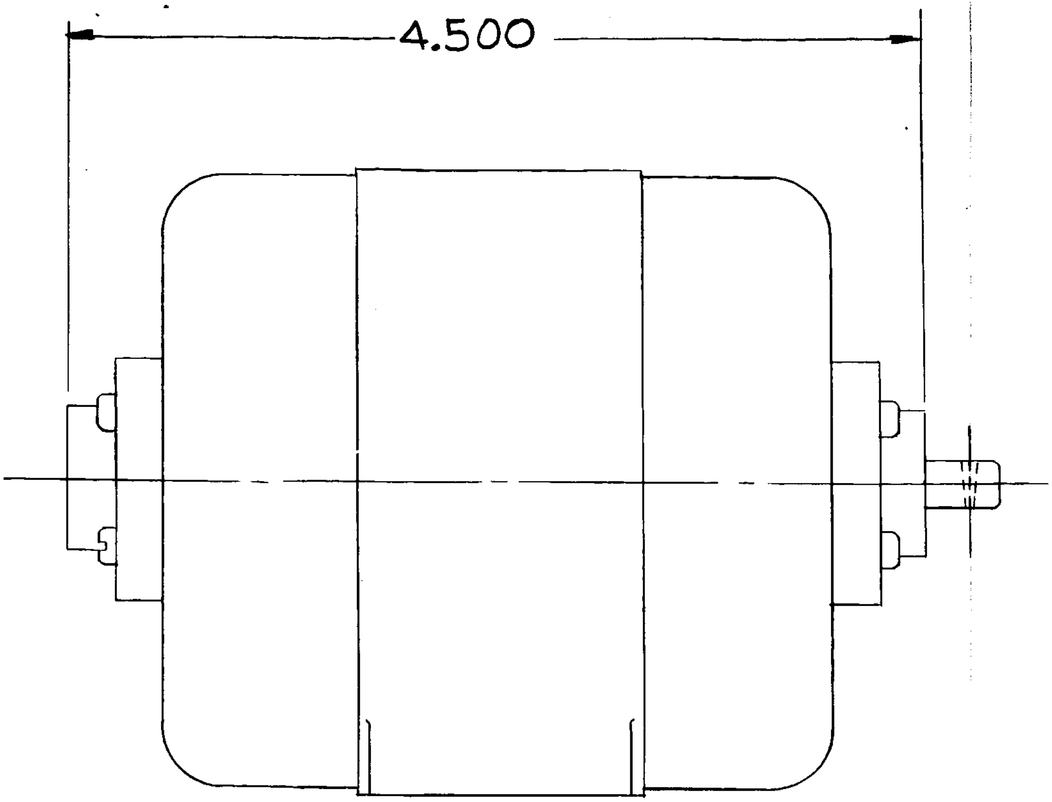
Figure 33. Reduction Gear Assembly
RCA Dwg 1723737 Rev B
(Sheet 3 of 3)

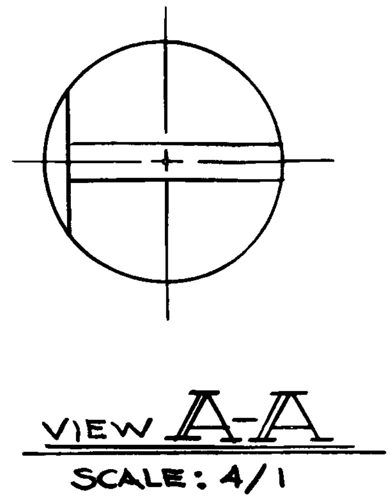


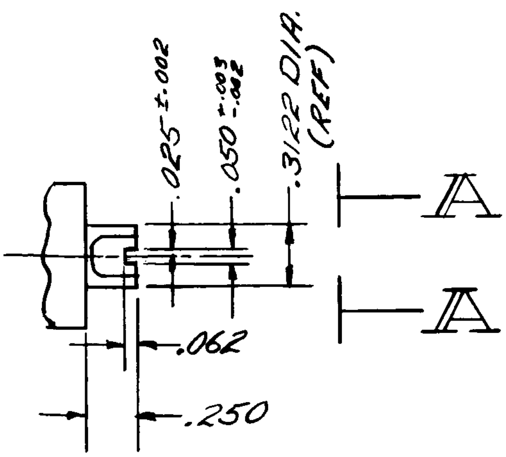
NOTES:

1. SHAFT IS ALTERED AS PER DETAIL.

1	BODINE ELECTRIC COMPANY, 2500 W. BRAD CHICAGO 18, ILLINOIS PART NO. NYC-12
DASH NO.	VENDOR

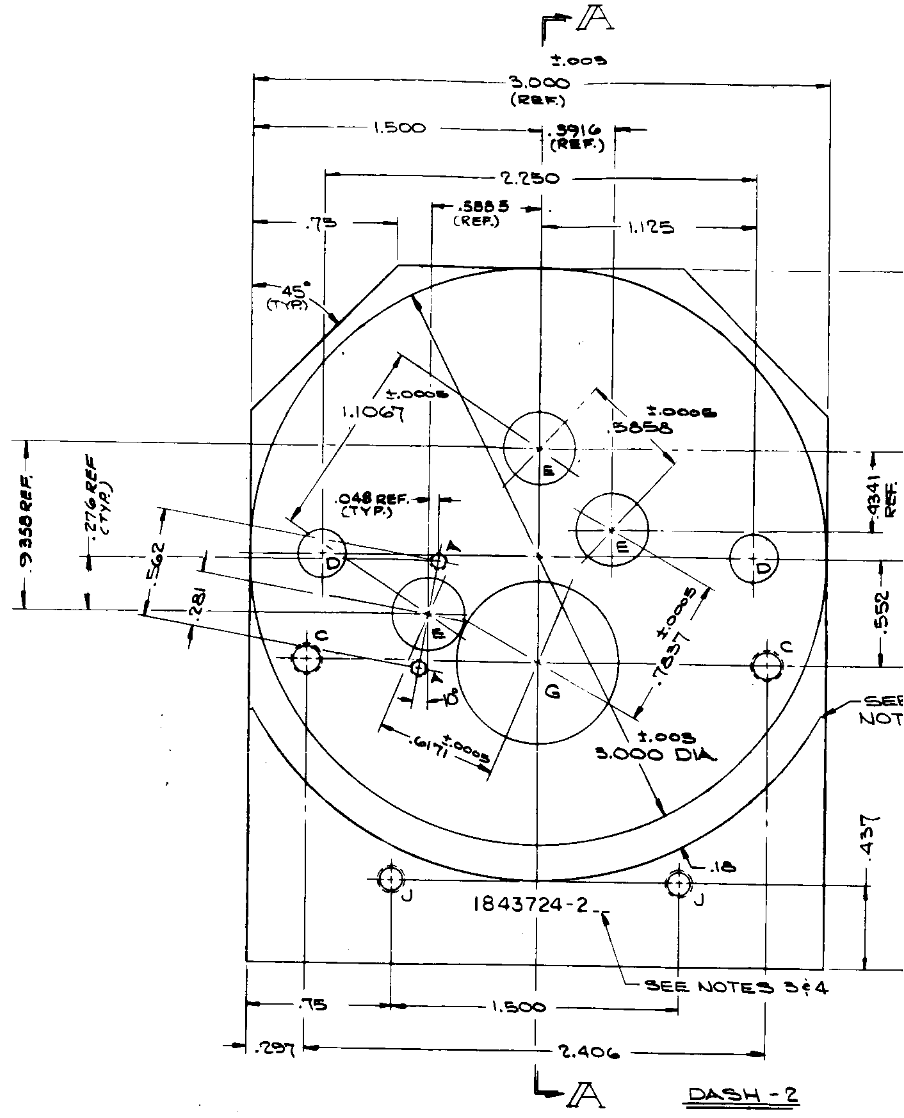






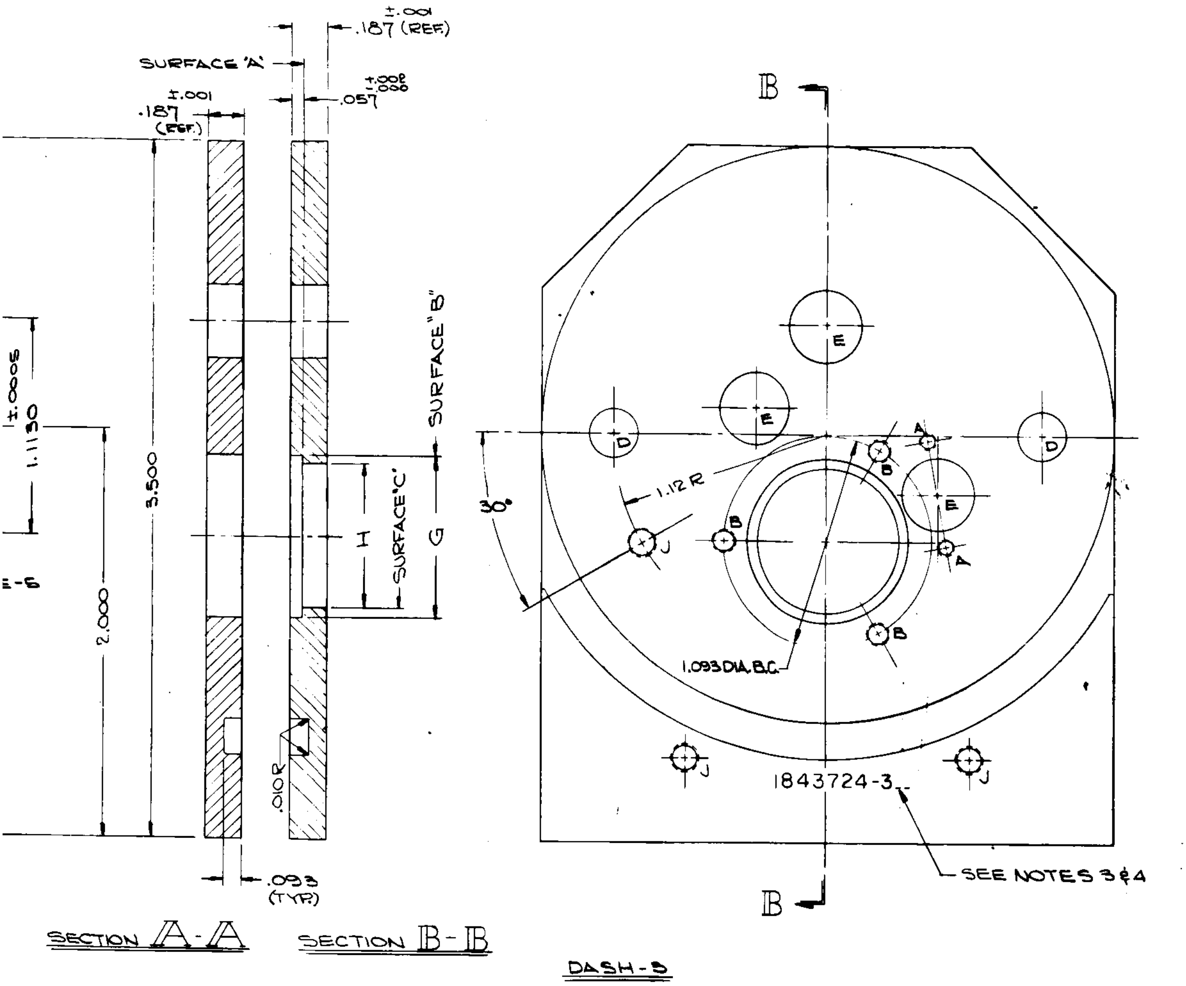
.EY PLACE

Figure 34. Motor Assembly RCA
Dwg 1848220 Rev B



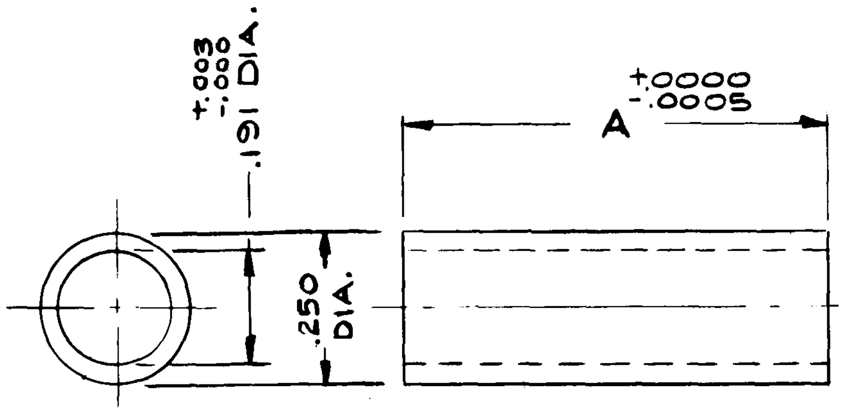
NOTES:

1. SURFACES "A" & "C" TO BE PERPENDICULAR WITHIN .001 TIR.
2. SURFACES "B" & "C" TO BE CONCENTRIC WITHIN .001 TIR.
3. DASH NO. 2 & 3 ARE TO BE LINE BORED, MATCHED PAIRS AND TO BE MARKED ACCORDINGLY. EACH PAIR SHALL HAVE IDENTICAL MARKING (METAL STAMPED) STARTING FROM 1843724-2A & 1843724-3A FOR THE FIRST PAIR, AND 1843724-2B & 1843724-3B FOR THE SECOND PAIR, ETC.
4. PART ORDERING INFORMATION; SERIALIZATION OF DASH NO'S 2 & 3 SHALL HAVE LETTERS A THRU R ALLOCATED FOR CONTRACT NO. NAS 5-667 AND SHALL NOT BE USED ON ANY OTHER CONTRACT NO. WITHOUT ENGINEERING AUTHORIZATION.
5. BREAK SHARP EDGES.



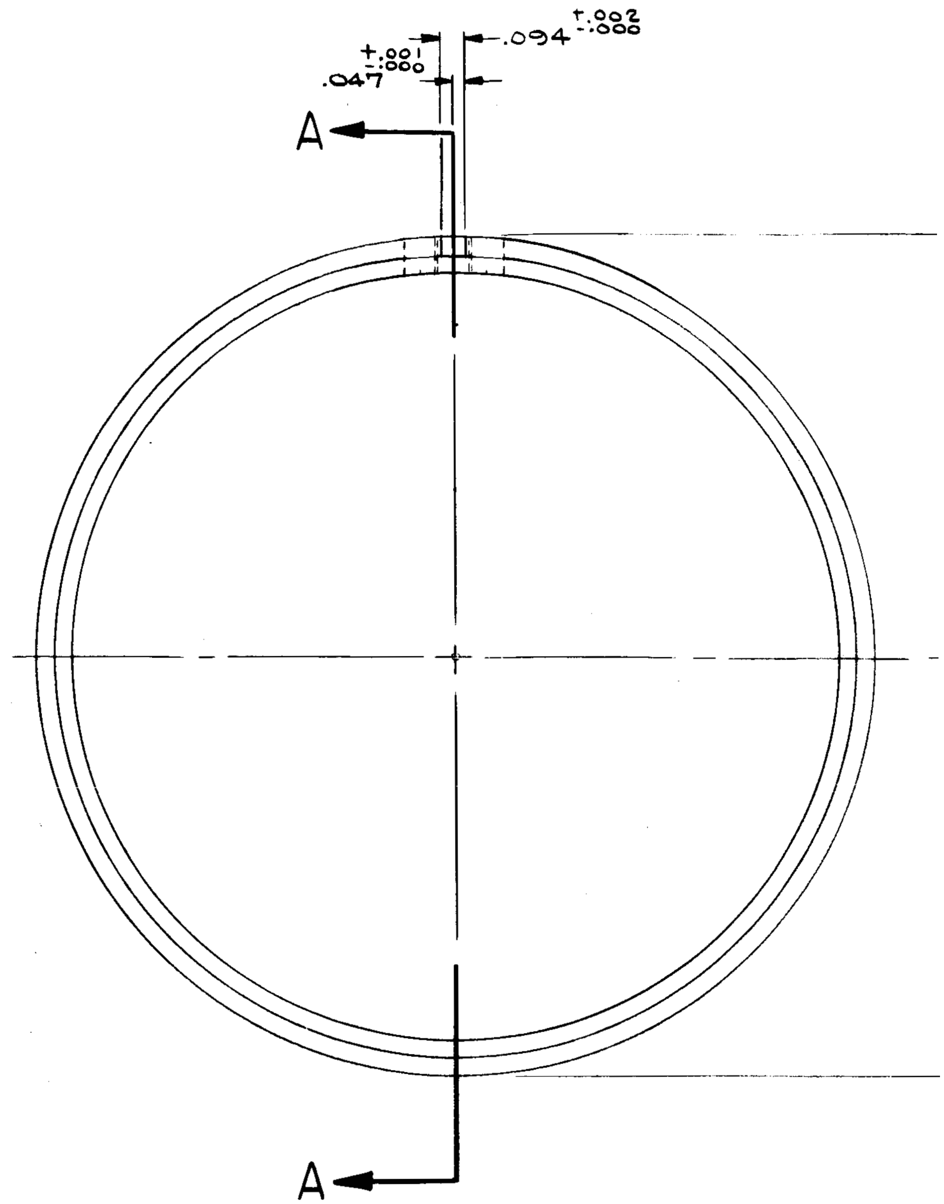
HOLE SCHEDULE				
HOLE	SIZE	QUANTITY DASH-2	QUANTITY DASH-3	REMARKS
A	2(.086)56 TAP	2	2	TAP THRU
B	4(.112)40 TAP	-	3	120° APART (AS SHOWN)
C	8(.164)32 TAP	2	-	TAP THRU
D	$.2500^{+.0001}_{-.0000}$ DIA	2	2	TO BE LINE BORED
E	$.3750^{+.0002}_{-.0000}$ DIA	3	3	TO BE LINE BORED
G	$.828^{+.002}_{-.000}$ DIA.	1	1	TO BE LINE BORED
H	$.7505^{+.0005}_{-.0000}$ DIA.	-	1	
J	6(.138)32 TAP	2	3	TAP THRU

Figure 35. Bearing Plate
RCA Dwg 1843724 Rev A



DASH NO.	"A"
1	1.218
2	1.093
3	.250
4	.218
5	.312

Figure 36. Spacer RCA Dwg 1847061 Rev A



NOTES:

1.- DIAMETERS 'C' & 'D' TO BE CONCENTRIC TO EACH OTHER WITHIN .001 T.I.R.

2.- SURFACES 'E' & 'F' TO BE PERPENDICULAR TO DIAMETERS 'C' & 'D' WITHIN .001 T.I.R.

#6-32 TAP THRU
(2 PLACES)

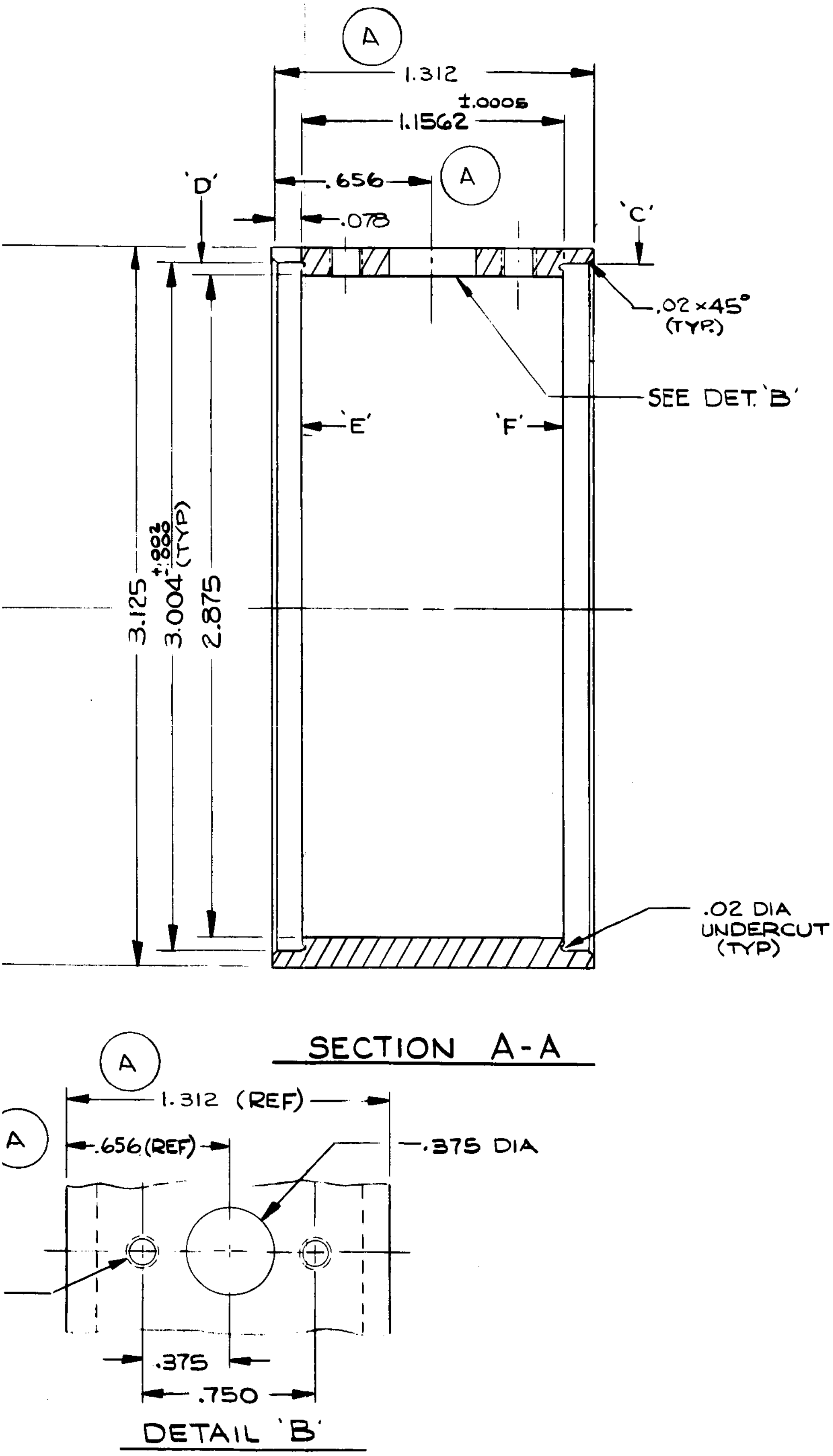
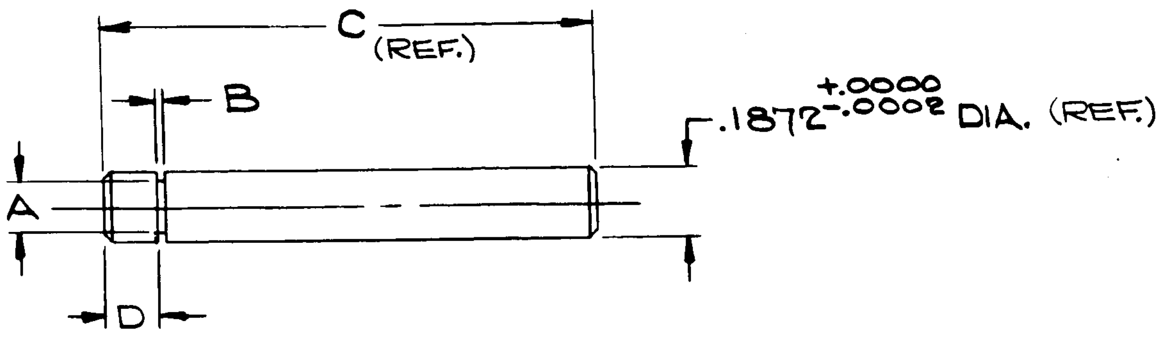
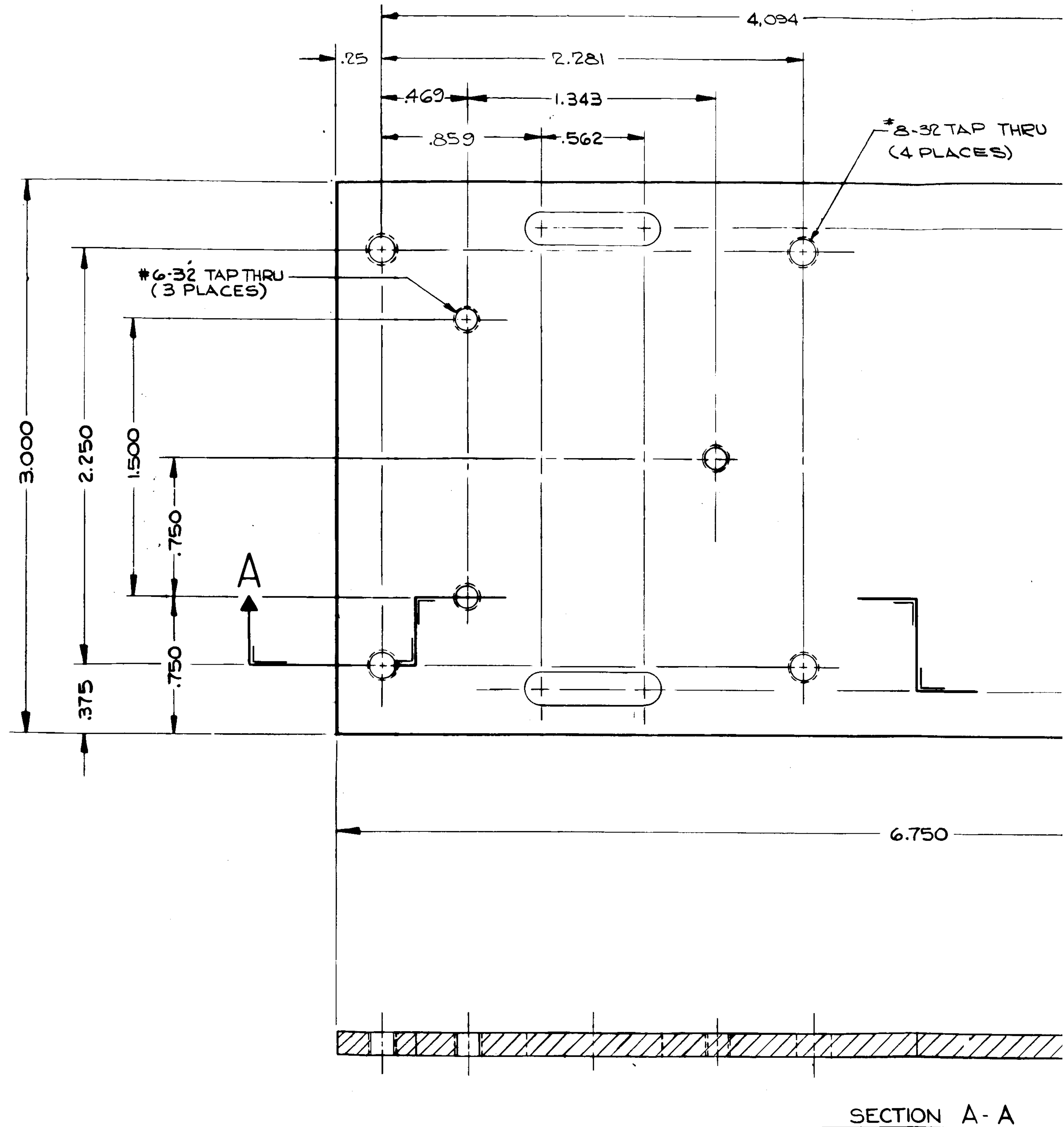


Figure 37. Gear Housing RCA
Dwg 1848212 Rev B



RCA DASH NO.	MAKE FROM PIC NO.	"A" DIA.	B	C	D
1	A2-22	$.175^{\pm.002}$	$.018^{+.003}_{-.000}$	2.25 ±.010	.19
2	A2-25	$.175^{\pm.002}$	$.018^{+.003}_{-.000}$	2.50 ±.010	.19

Figure 38. Shaft RCA Dwg 1847063



4.094
.25
2.281
.469
1.343
.859
.562
#8-32 TAP THRU
(4 PLACES)
#6-32 TAP THRU
(3 PLACES)
3.000
2.250
1.500
.750
.750
.375
A
6.750
SECTION A-A

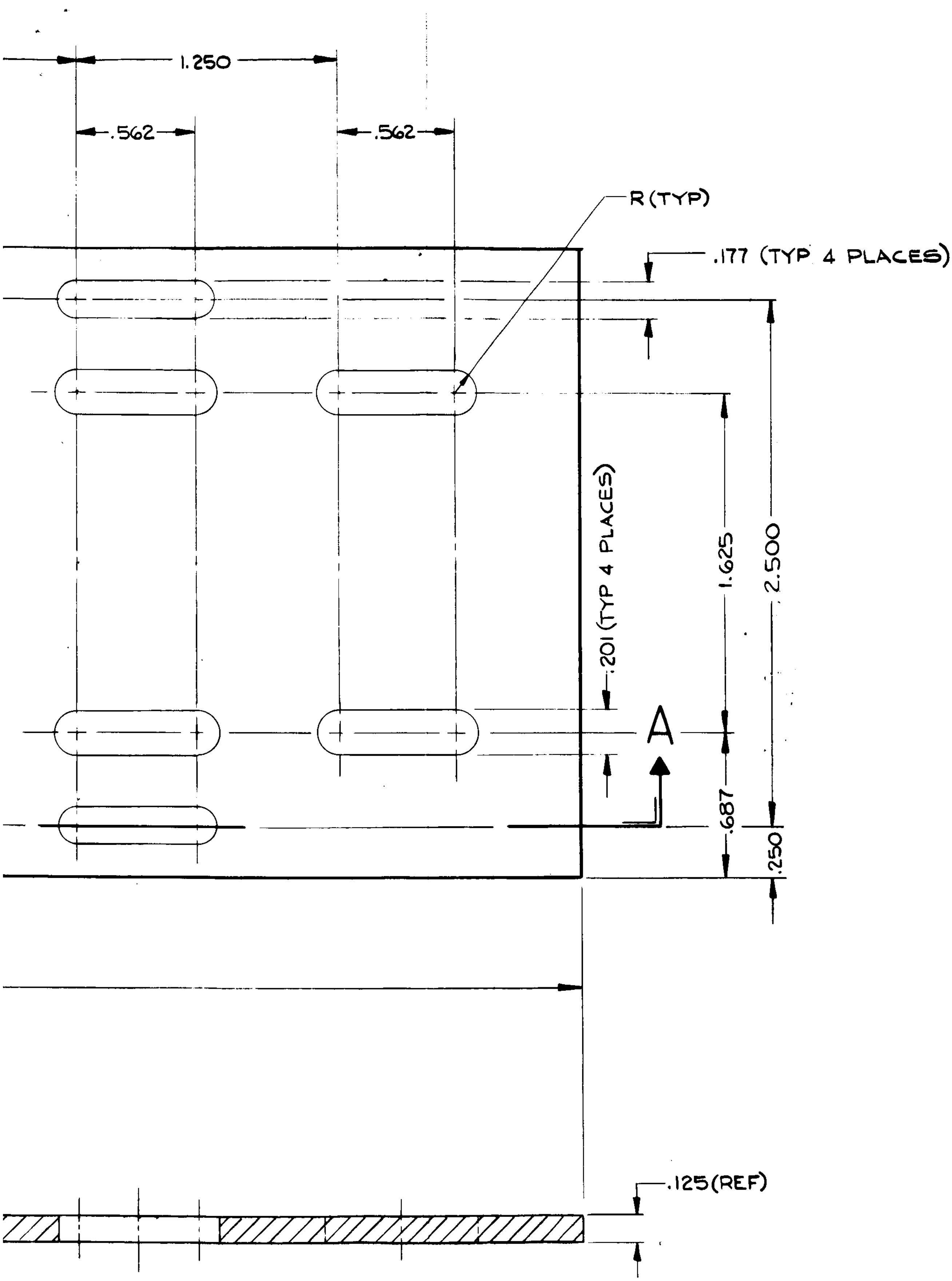
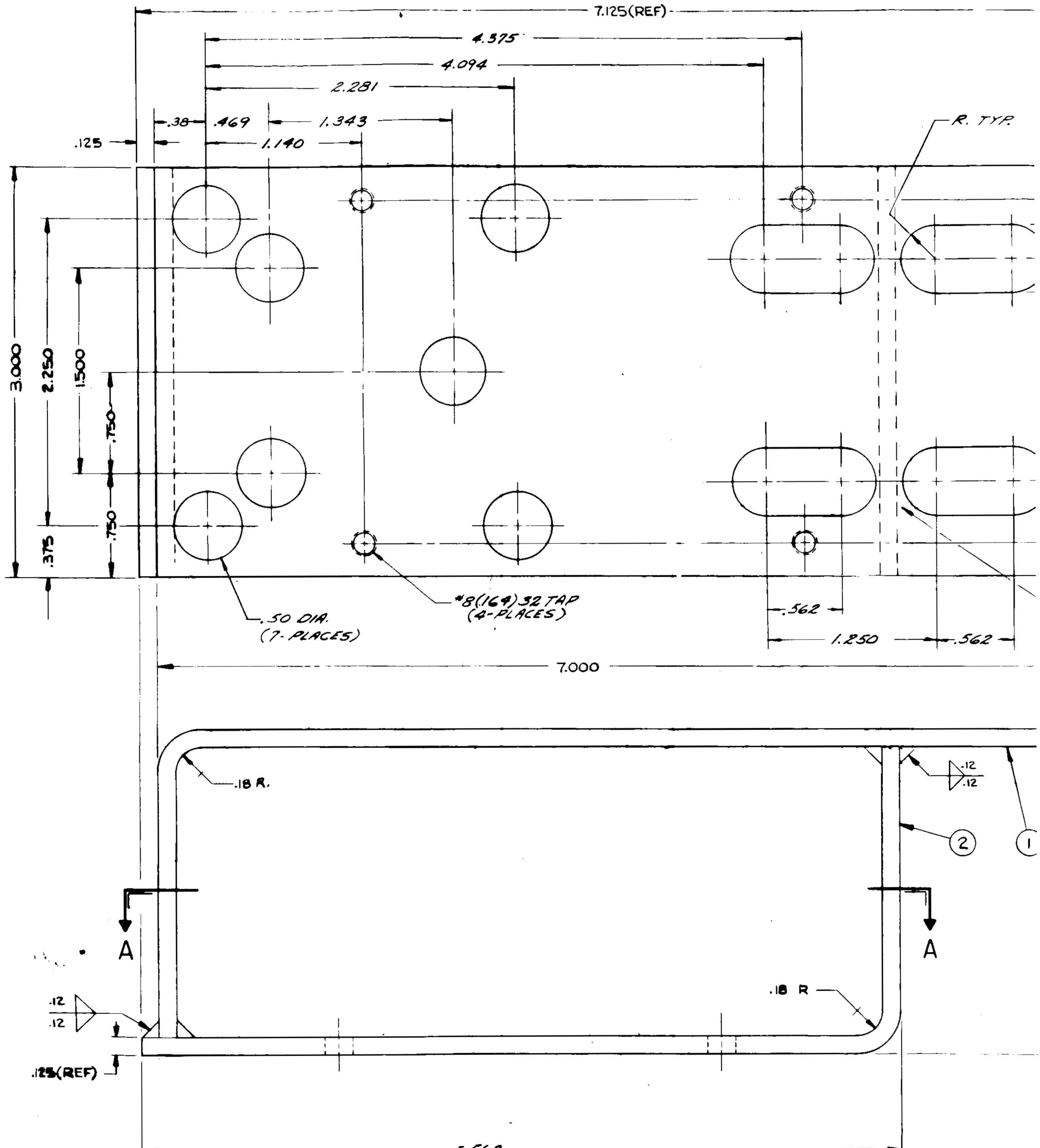


Figure 39. Base Plate RCA
Dwg 1843722


7.125(REF)
4.375
4.094
2.281
.38
.469
1.343
.125
1.140
R. TYP.
3.000
2.250
1.500
.750
.750
.375
.50 DIA. (7-PLACES)
#8(164)32 TAP (4-PLACES)
.562
1.250
.562
7.000
.18 R.
.12
.12
2
1
A
A
.12
.12
.18 R
.125(REF)
5.563

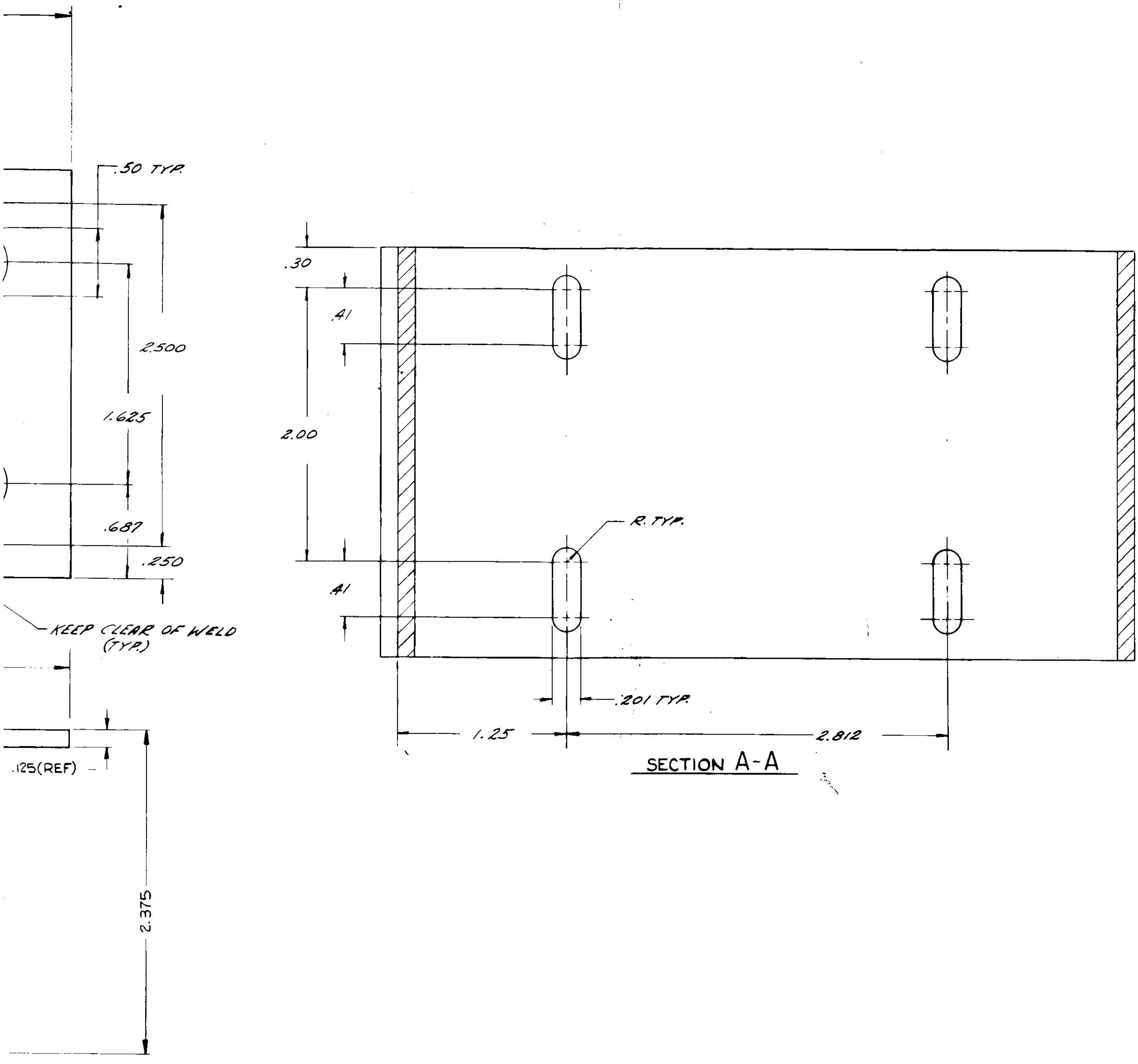
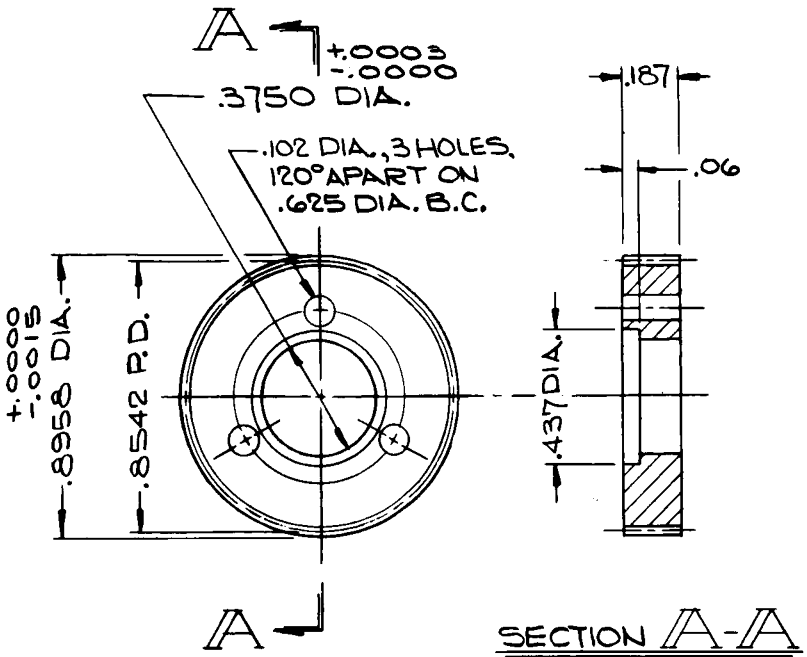


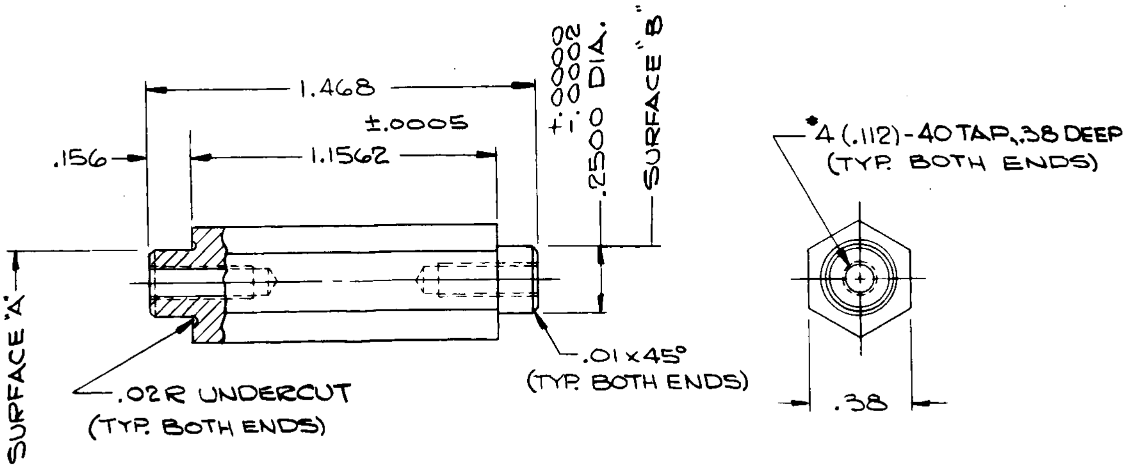
Figure 40. Mounting Bracket
RCA Dwg 1843723



NOTES:

1. GEAR DATA: 48 PITCH, 41 TEETH, 20° PRESSURE ANGLE, PRECISION 2, TOTAL COMPOSITE ERROR .0005, TOOTH TO TOOTH COMPOSITE ERROR .0003.

Figure 41. Spur Gear, 41 Teeth RCA Dwg 1847062



NOTES:

1. SURFACES "A" & "B" TO BE CONCENTRIC WITHIN .001 TIR.

Figure 42. Stand Off, RCA Dwg 1847060 Rev A

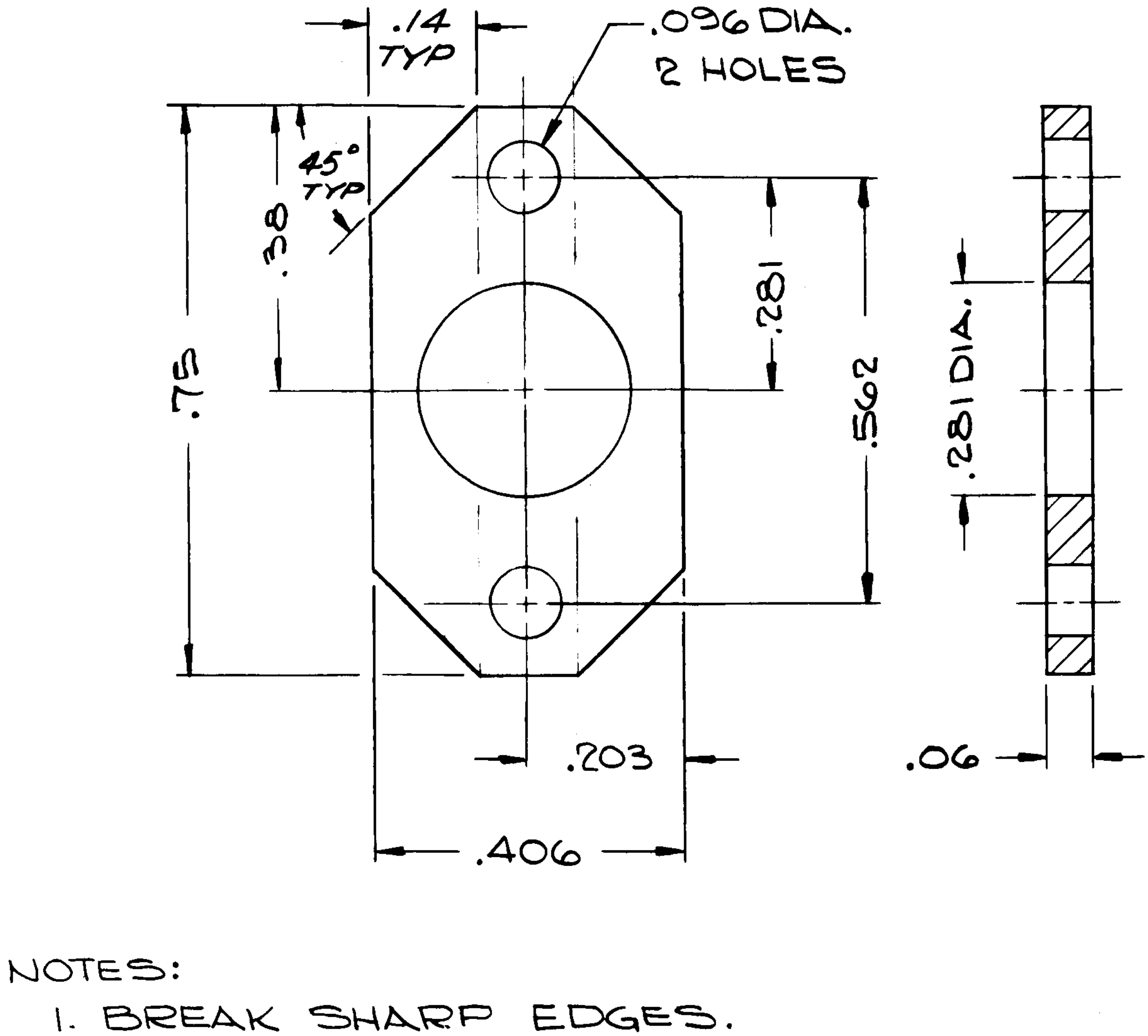
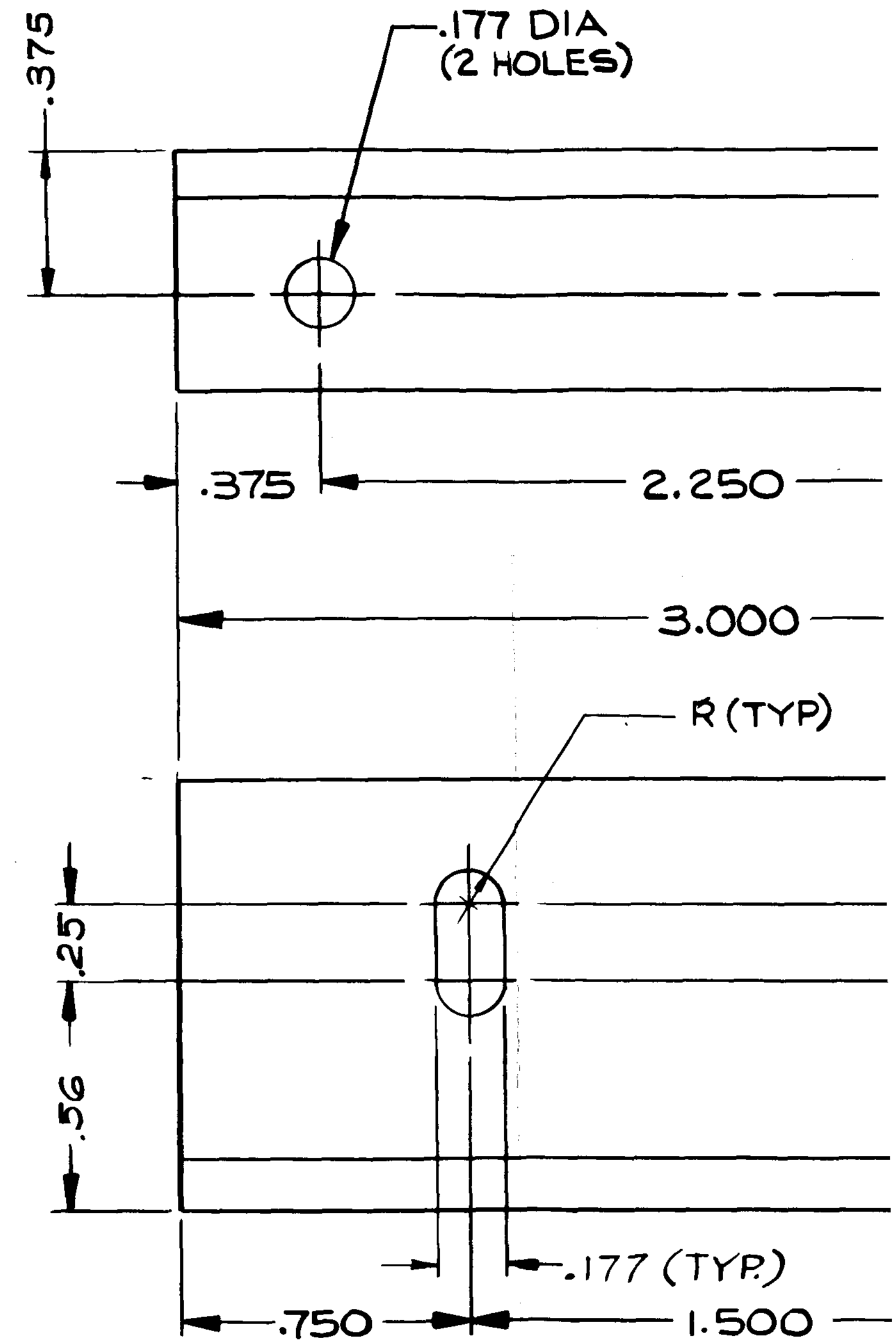


Figure 43. Bearing Retainer RCA Dwg 1847064 Rev B



.177 DIA
(2 HOLES)
.375
.375
2.250
3.000
R (TYP)
.25
.56
.177 (TYP.)
.750
1.500

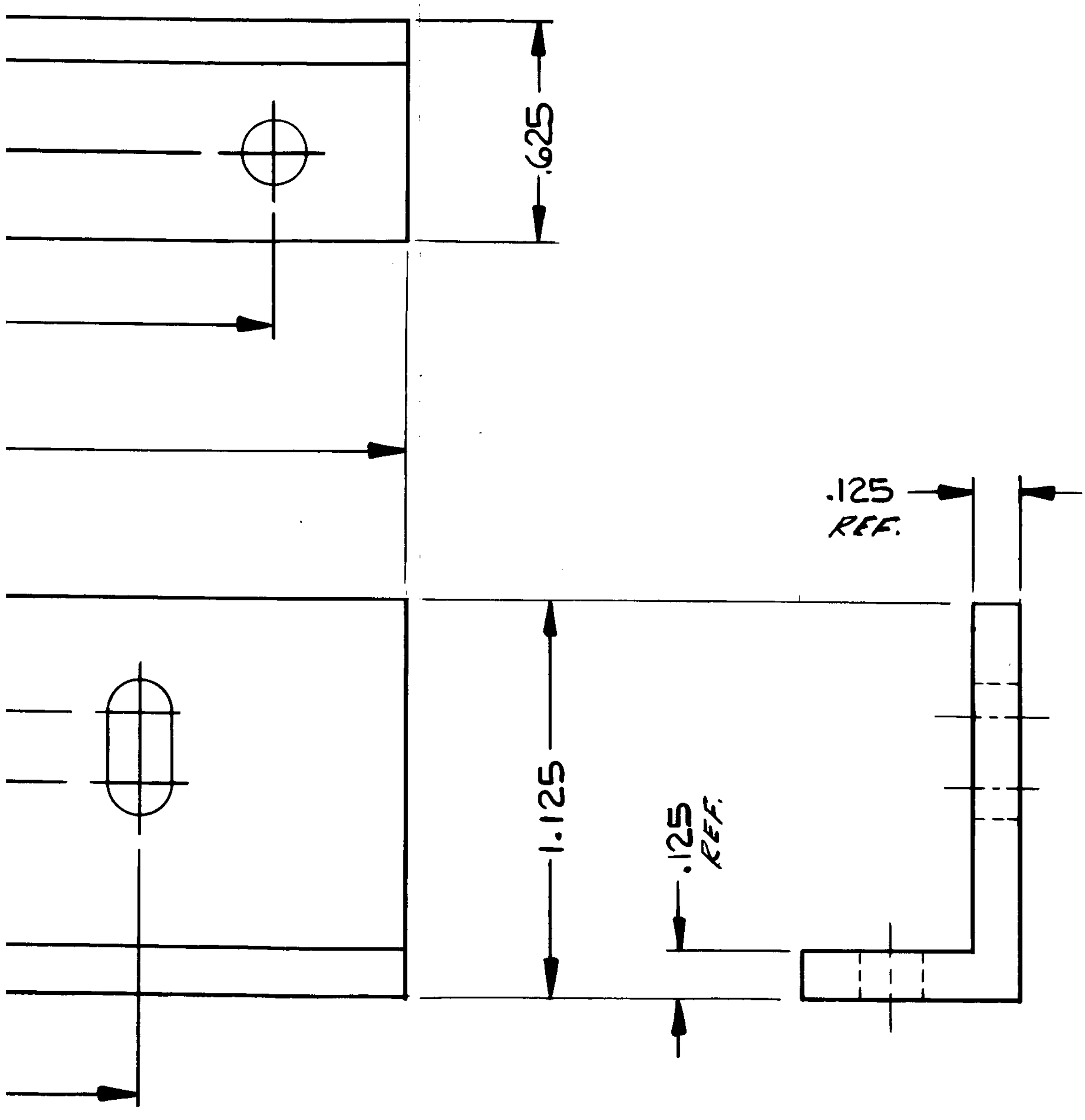
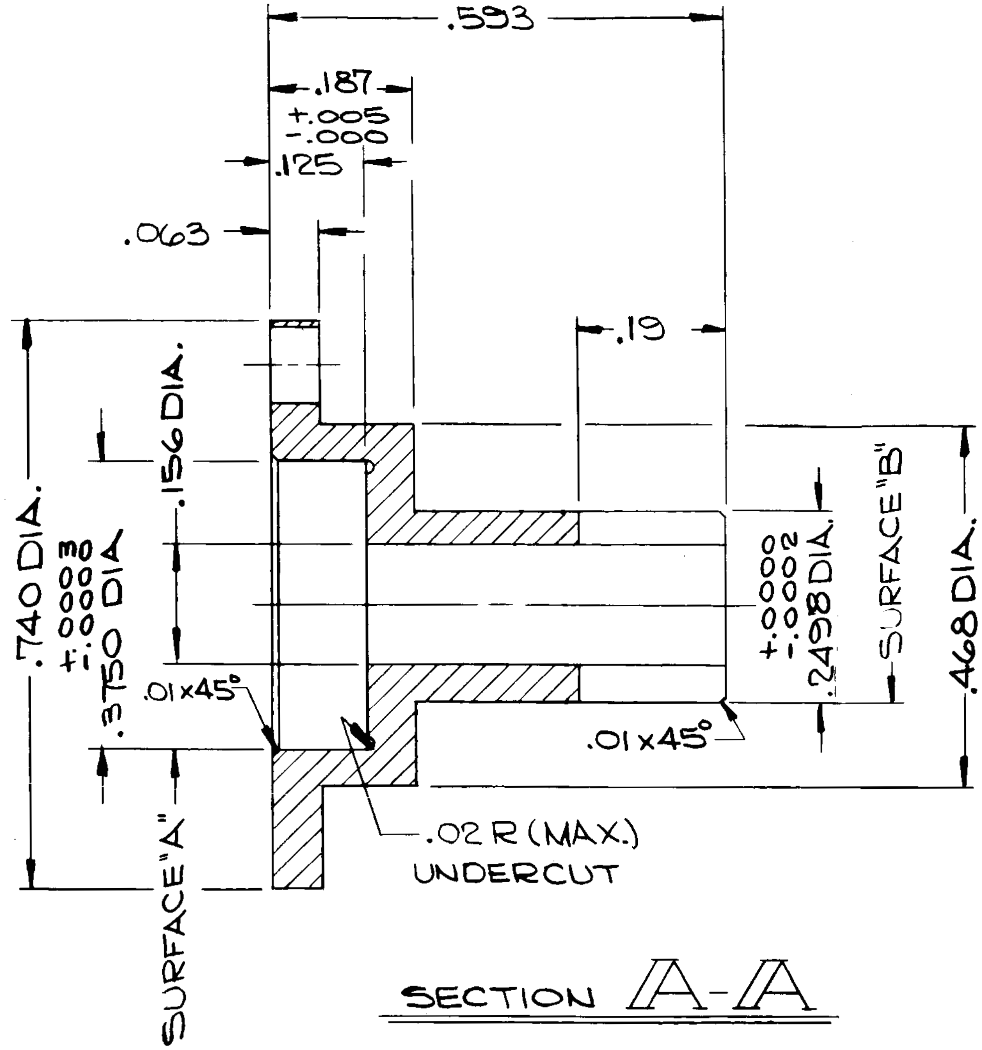


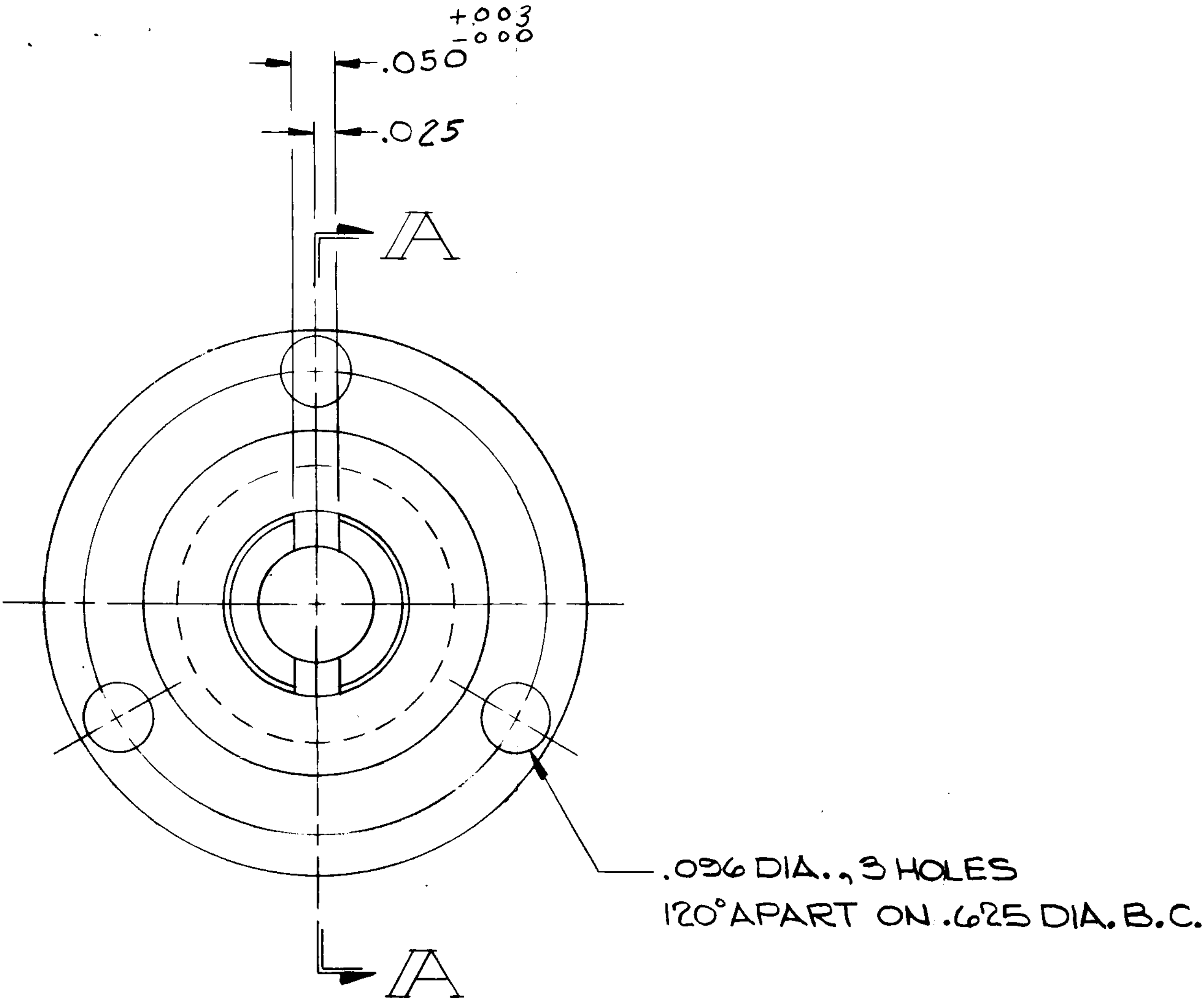
Figure 44. Bracket RCA Dwg 1848213



SECTION A-A

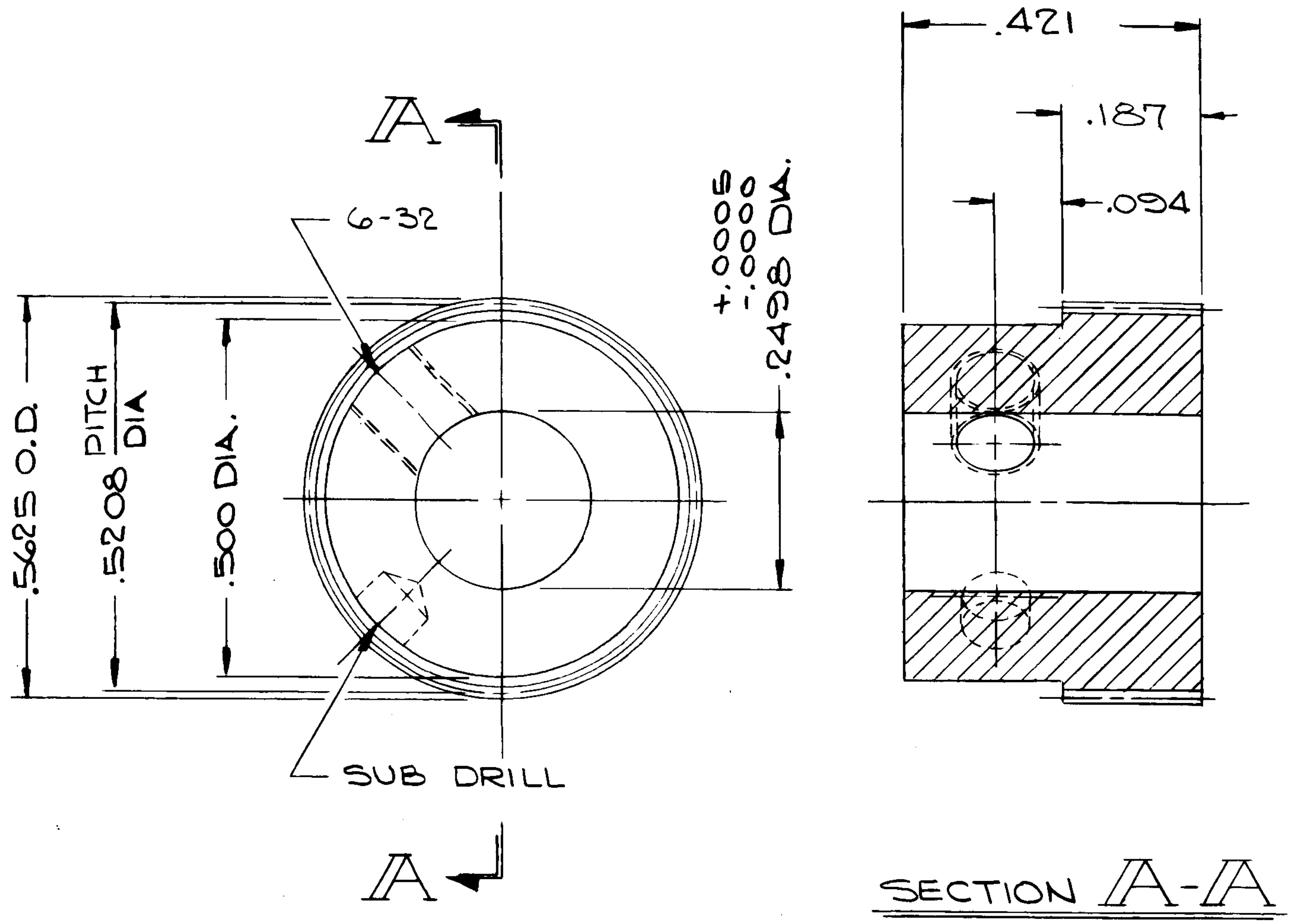
NOTES:

1. SURFACES "A" & "B" TO BE CONCENTRIC WITHIN .0005



TIR.

Figure 45. Adapter, Gear-to-Clutch
RCA Dwg 1848208



DASH-1

NOTES:

1. GEAR DATA: 48 PITCH, 25 TEETH, 20° PRESSURE ANGLE, PRECISION 2, TOTAL COMPOSITE ERROR .0005, TOOTH TO TOOTH COMPOSITE ERROR .0003.

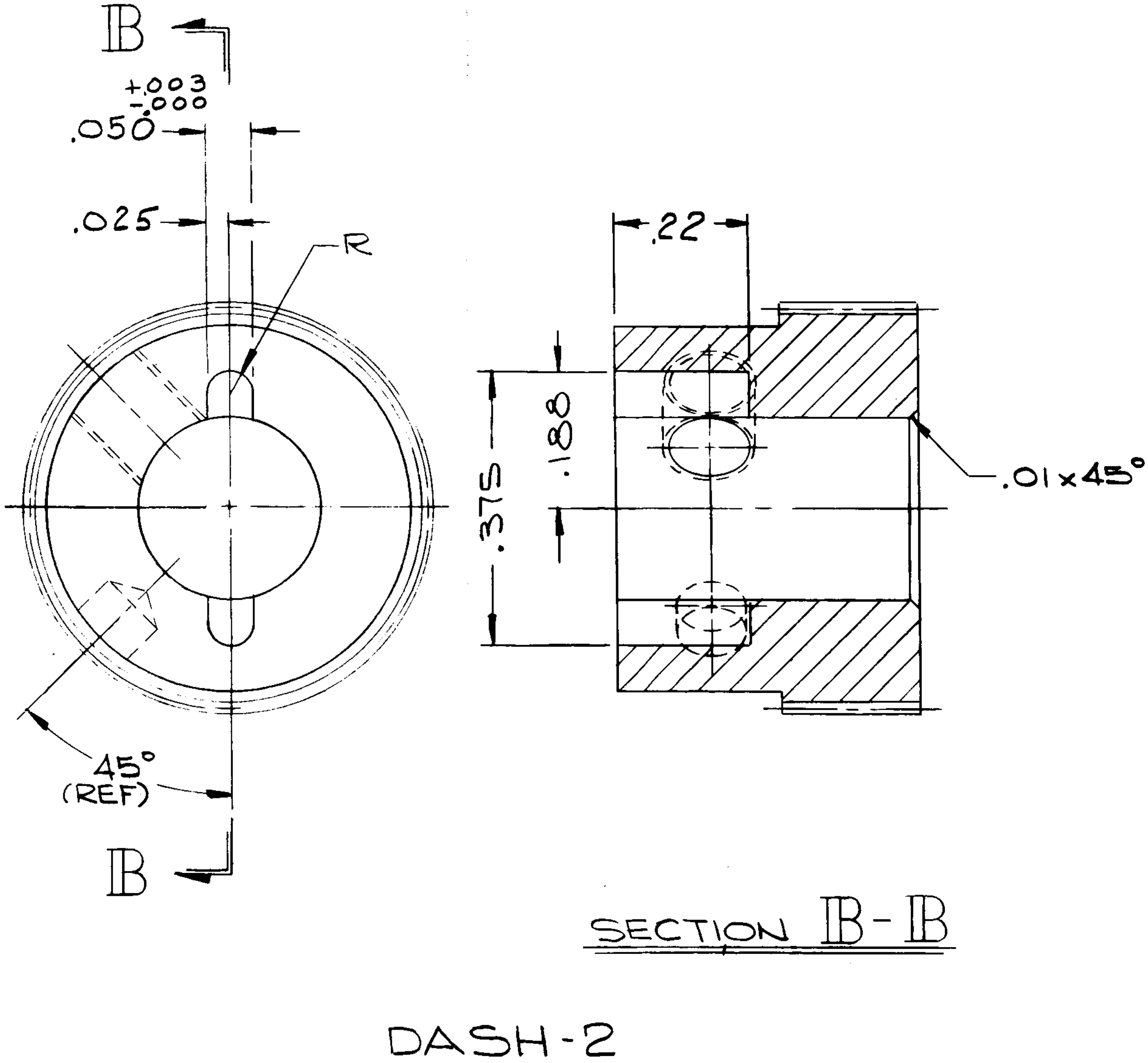


Figure 46. Spur Gear, 25 Teeth
RCA Dwg 1848209

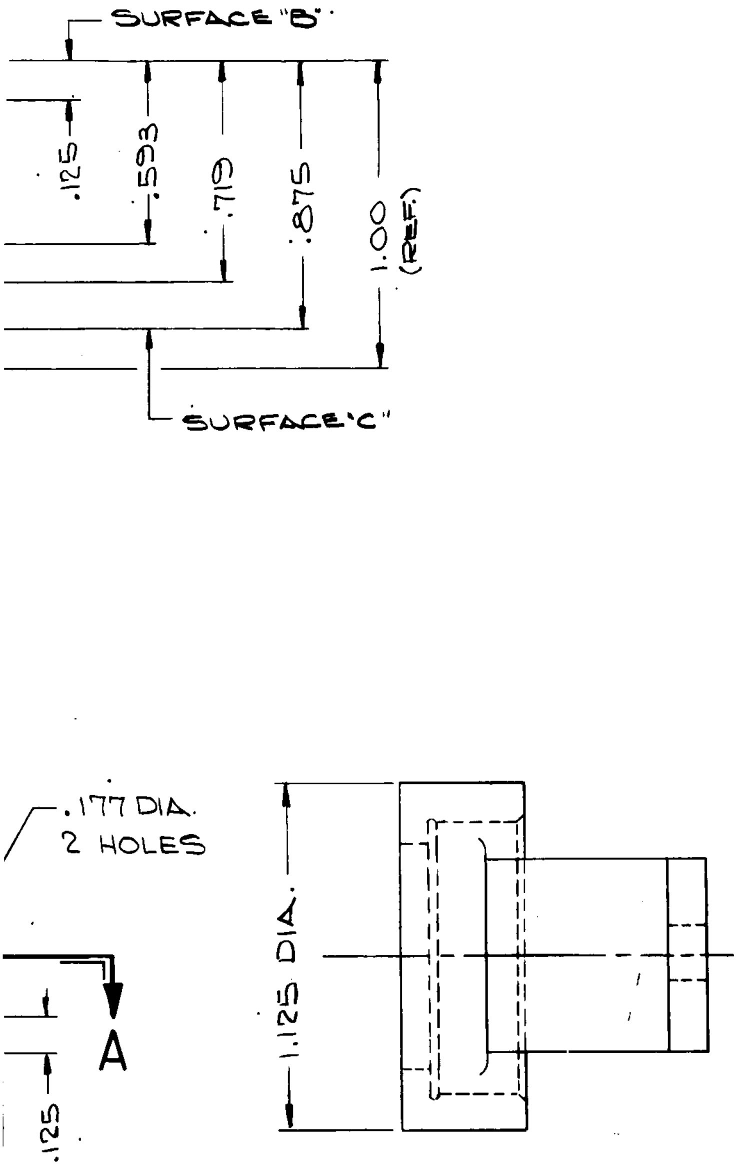
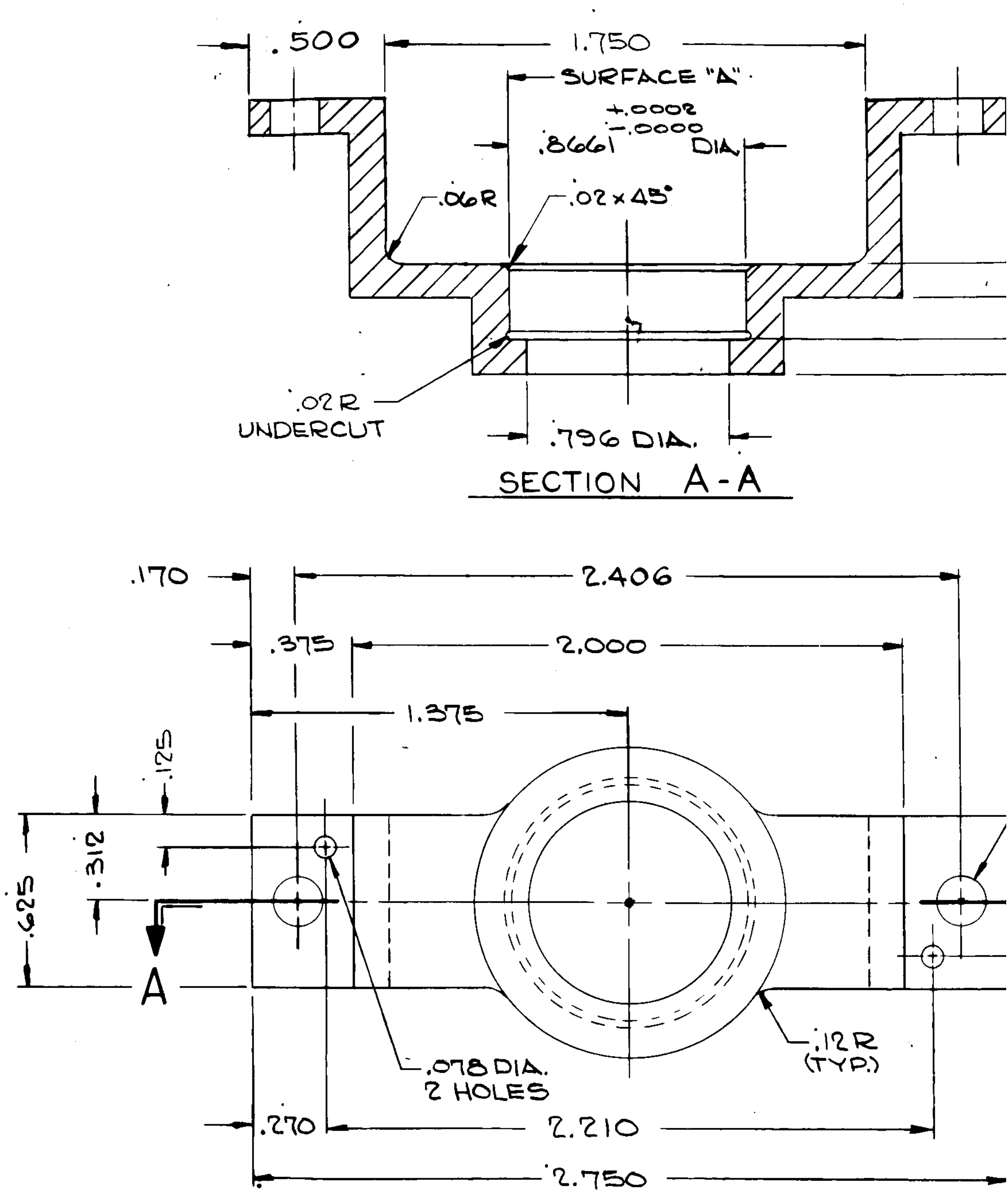


Figure 47. Bearing Retainer
RCA Dwg 1848216



NOTES:

1. SURFACES "A" & "C" TO BE PERPENDICULAR TO EACH OTHER WITHIN .001 TIR.
2. SURFACES "B" & "C" TO BE PARALLEL TO EACH OTHER WITHIN .001 TIR.
3. BREAK SHARP EDGES.

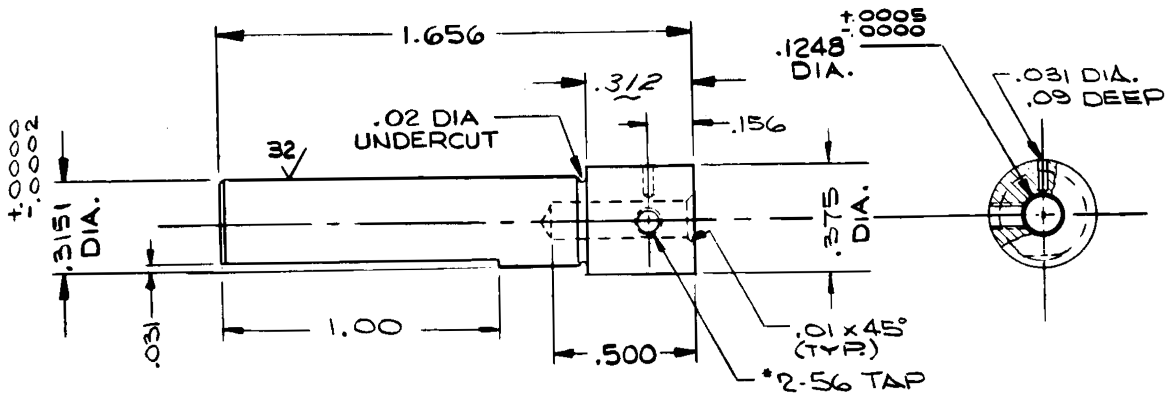
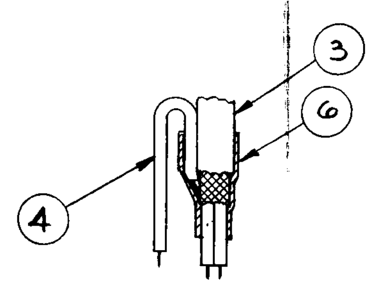
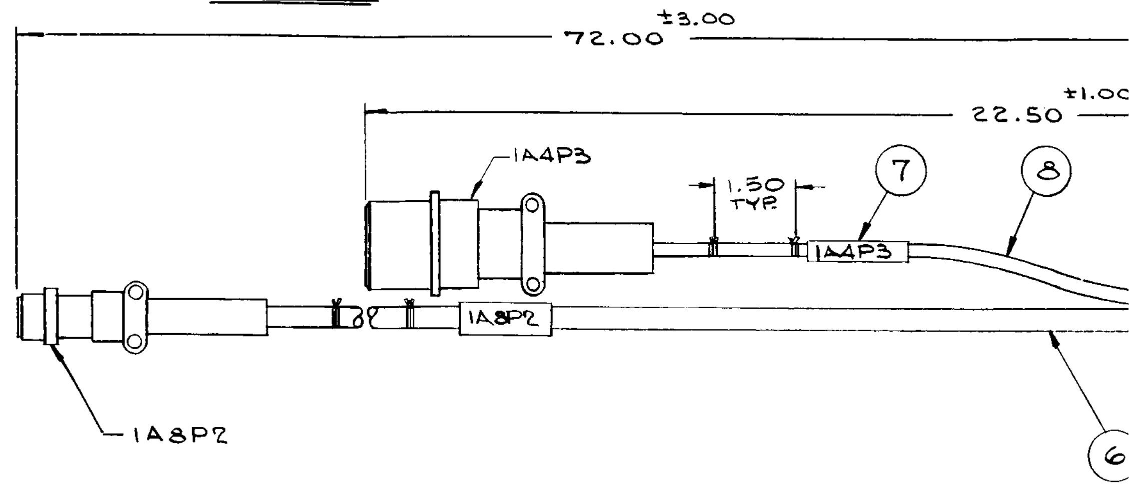


Figure 48. Shaft RCA Dwg 1847069 Rev A



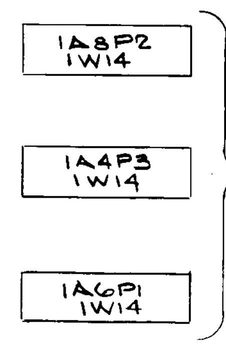
DETAIL A



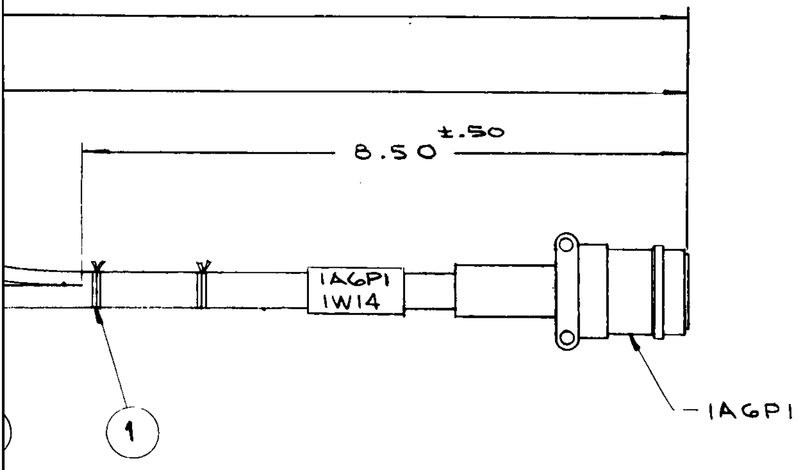
SEE DETAIL A

SEE DETAIL A

CONNECTION LIST			
ITEM	FROM	TO	TO
2	1A6P1-3	1A8P2-10	———
2	1A6P1-4	1A8P2-11	———
2	1A6P1-10	1A8P2-9	———
2	1A6P1-13	1A8P2-3	———
2	1A6P1-14	1A8P2-4	———
3(SHLD)	1A6P1-37	———	1A4P3-M
3 (WHT)	1A6P1-20	———	1A4P3-K
3 (BLK)	1A6P1-21	———	1A4P3-A
2	1A6P1-23	———	1A4P3-B
2	1A6P1-24	———	1A4P3-C
2	1A6P1-25	———	1A4P3-D
2	1A6P1-26	———	1A4P3-E
2	1A6P1-28	1A8P2-12	———
2	1A6P1-29	1A8P2-13	———
2	1A6P1-30	1A8P2-14	———
2	1A6P1-31	1A8P2-15	———
2	1A6P1-32	1A8P2-16	———
2	1A6P1-33	1A8P2-5	———
3(WHT)	1A6P1-34	1A8P2-18	———
3(BLK)	1A6P1-35	1A8P2-19	———
3(SHLD)	1A6P1-18	1A8P2-8	———



ITEM-7



ALL CHARACTERS TO BE .09 HIGH HEAT STAMPED AT APPROX. LOCATION SHOWN.

Figure 49. Adapter Harness 1W14
RCA Dwg 1848271

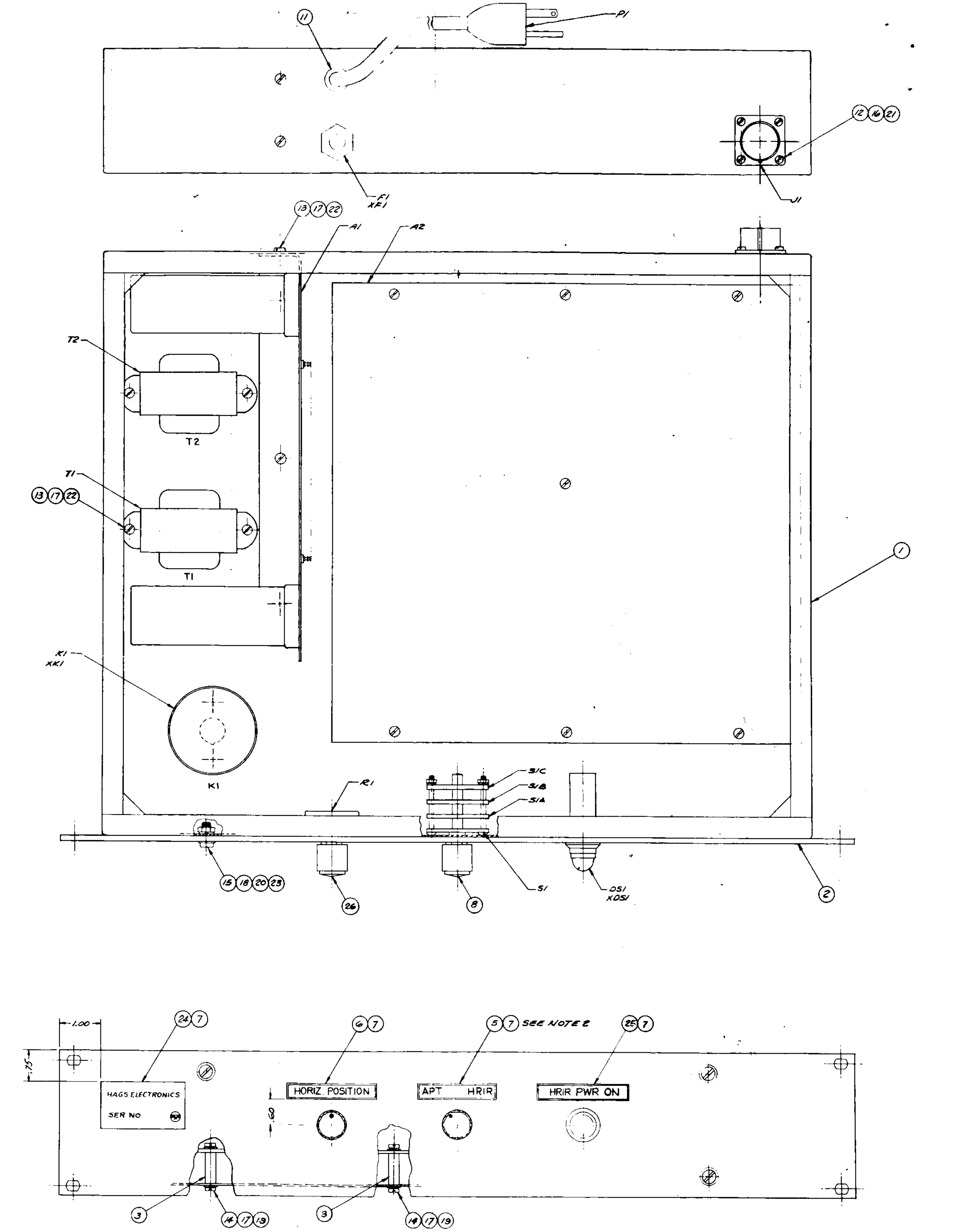
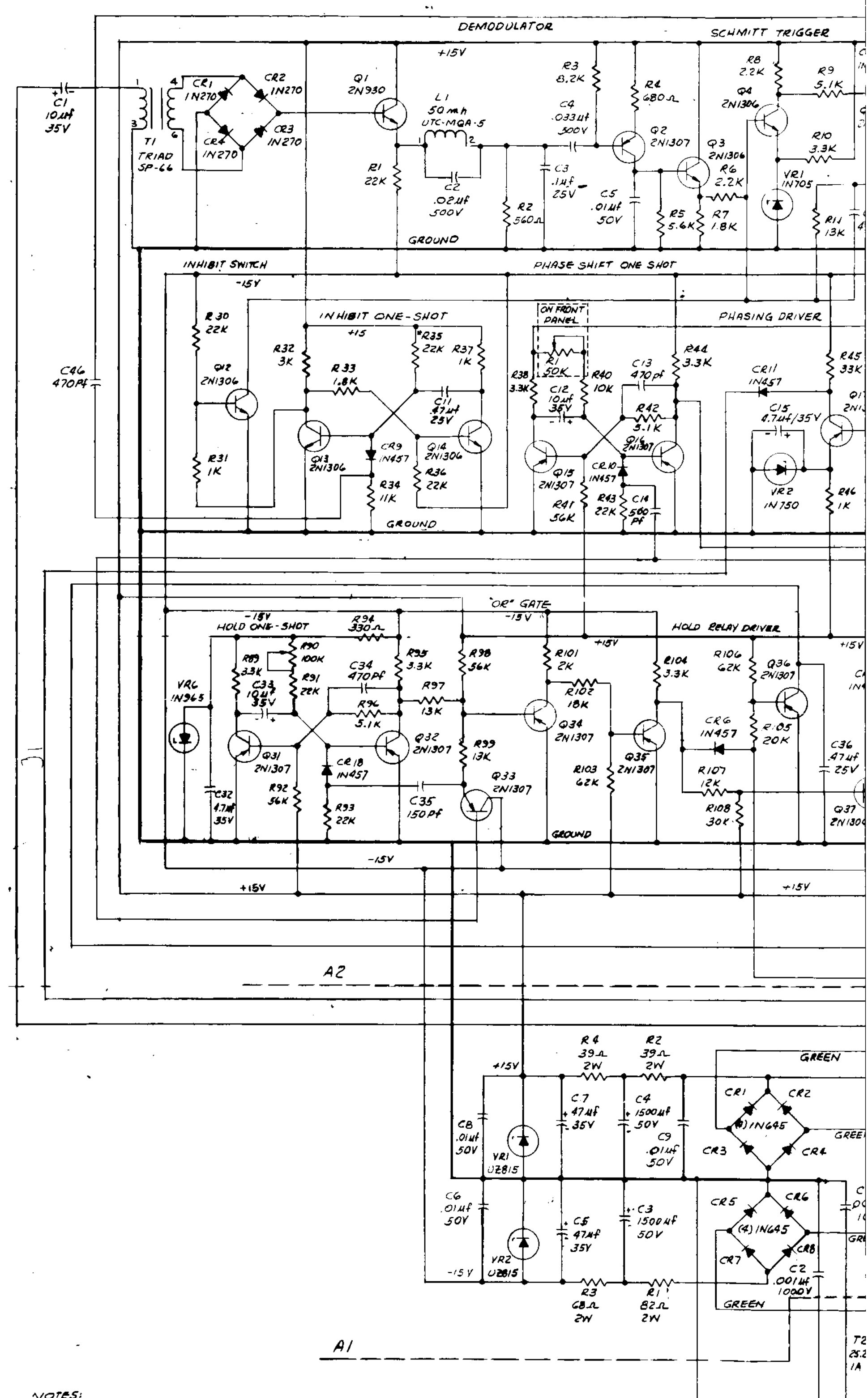


Figure 50. HRIR Converter Assembly
RCA Dwg 1723499 Rev A



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/2 WATT.
2. SWITCH S1 IS SHOWN IN APT POSITION
3. SELECT R51 FOR 37.0 MILLISEC.±5% AT Q18 COLLECTOR DURING TEST (APPROX. 10K)
4. SELECT R38 FOR 80.0 MILLISEC.±2% AT CONTACTS OF K1 DURING TEST (APPROX. 10K)
5. SELECT R35 FOR 10.0 MILLISEC.±5% AT Q13 COLLECTOR DURING TEST (APPROX. 22K)
6. # INDICATES THESE ITEMS TO BE SELECTED DURING TEST SEE NOTES 3, 4 & 5.

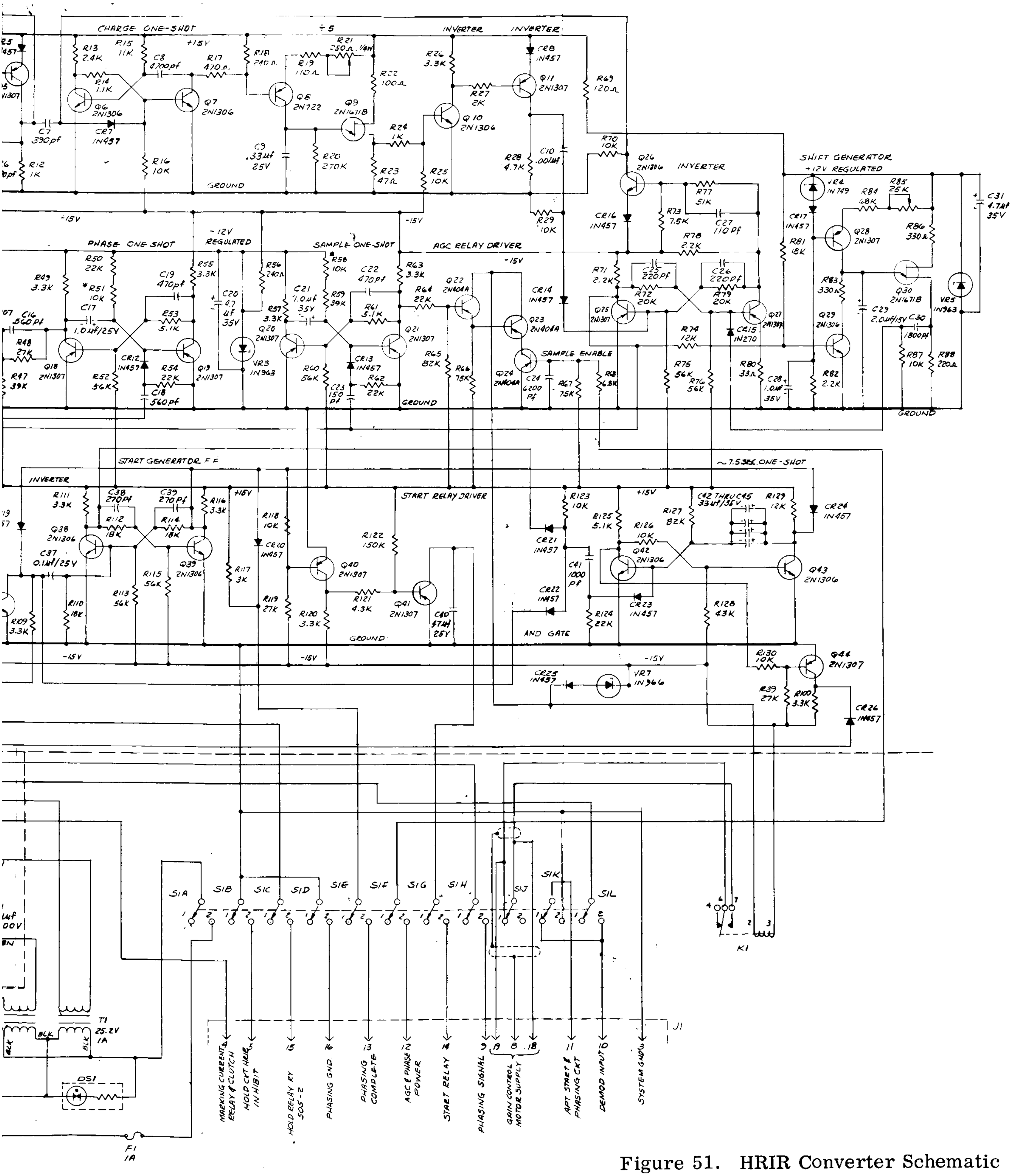
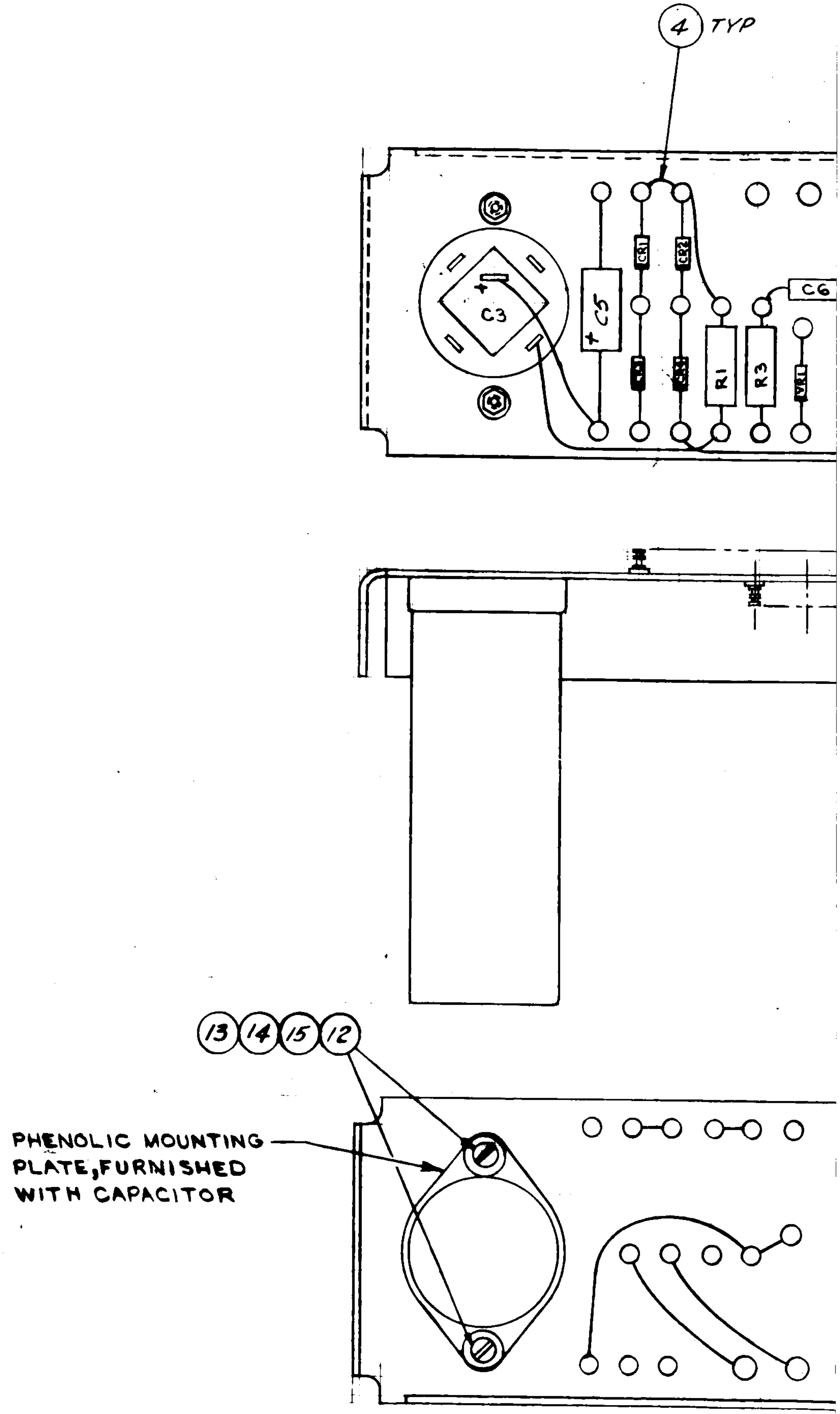


Figure 51. HRIR Converter Schematic
RCA Dwg 1723763



4 TYP
C3
C5
CR1
CR2
C6
R1
R3
13
14
15
12
PHENOLIC MOUNTING
PLATE, FURNISHED
WITH CAPACITOR

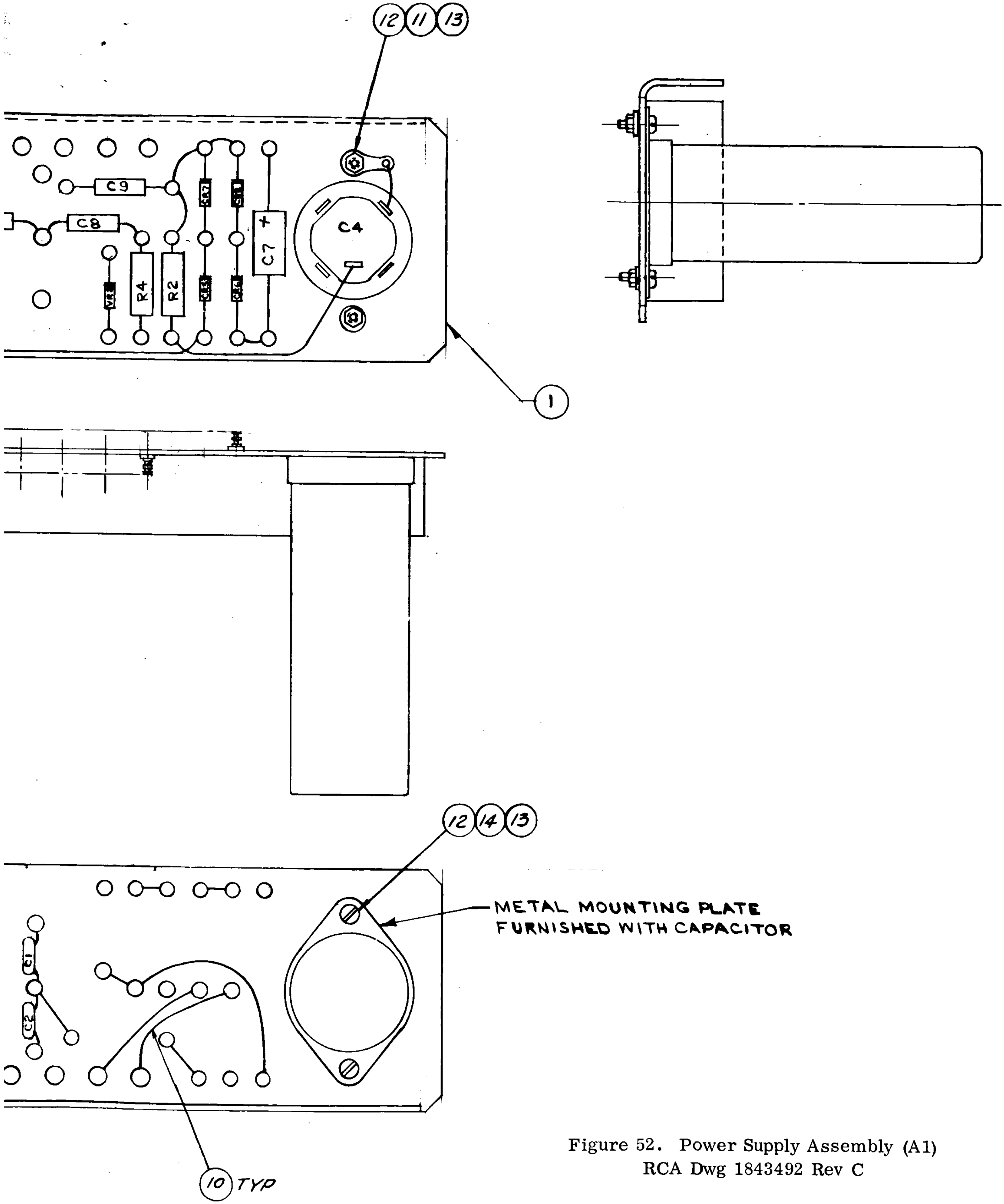
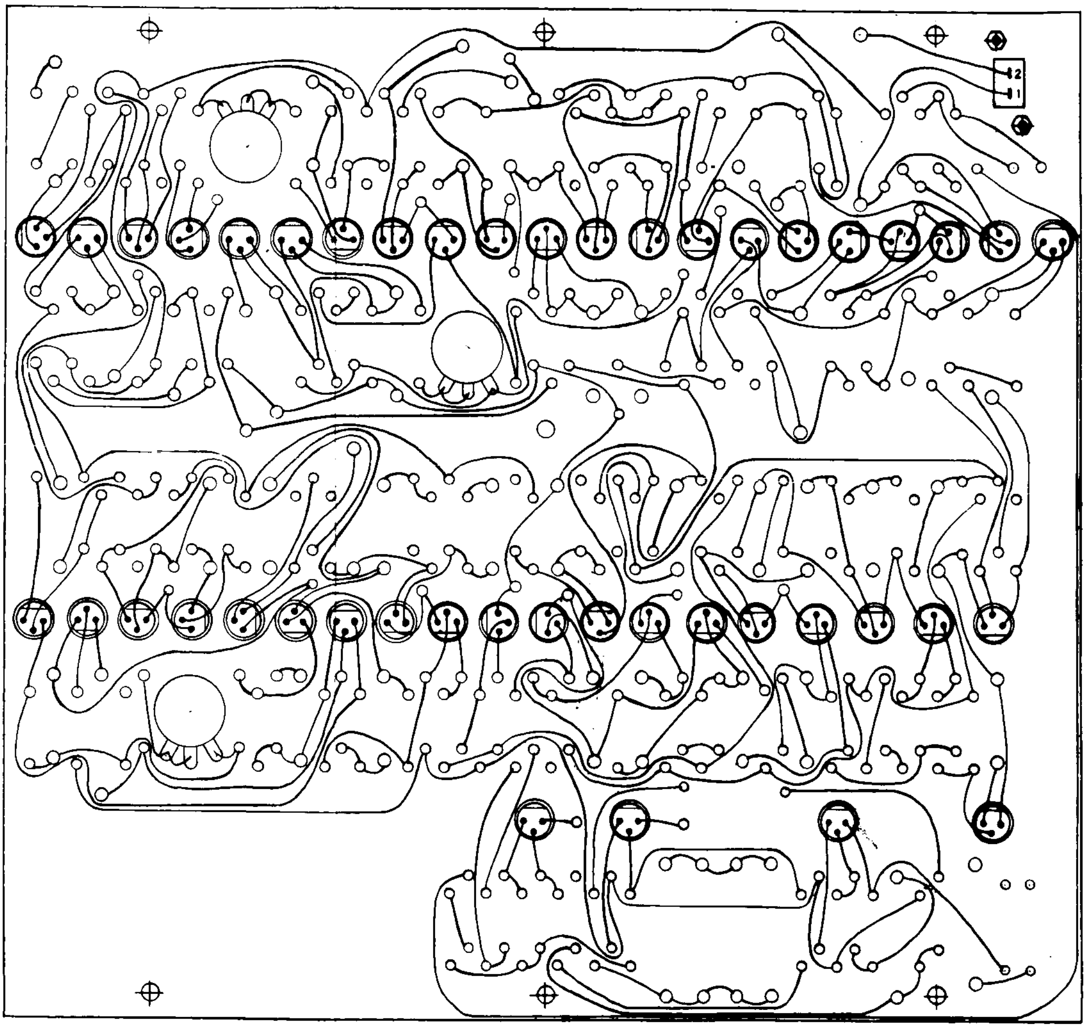
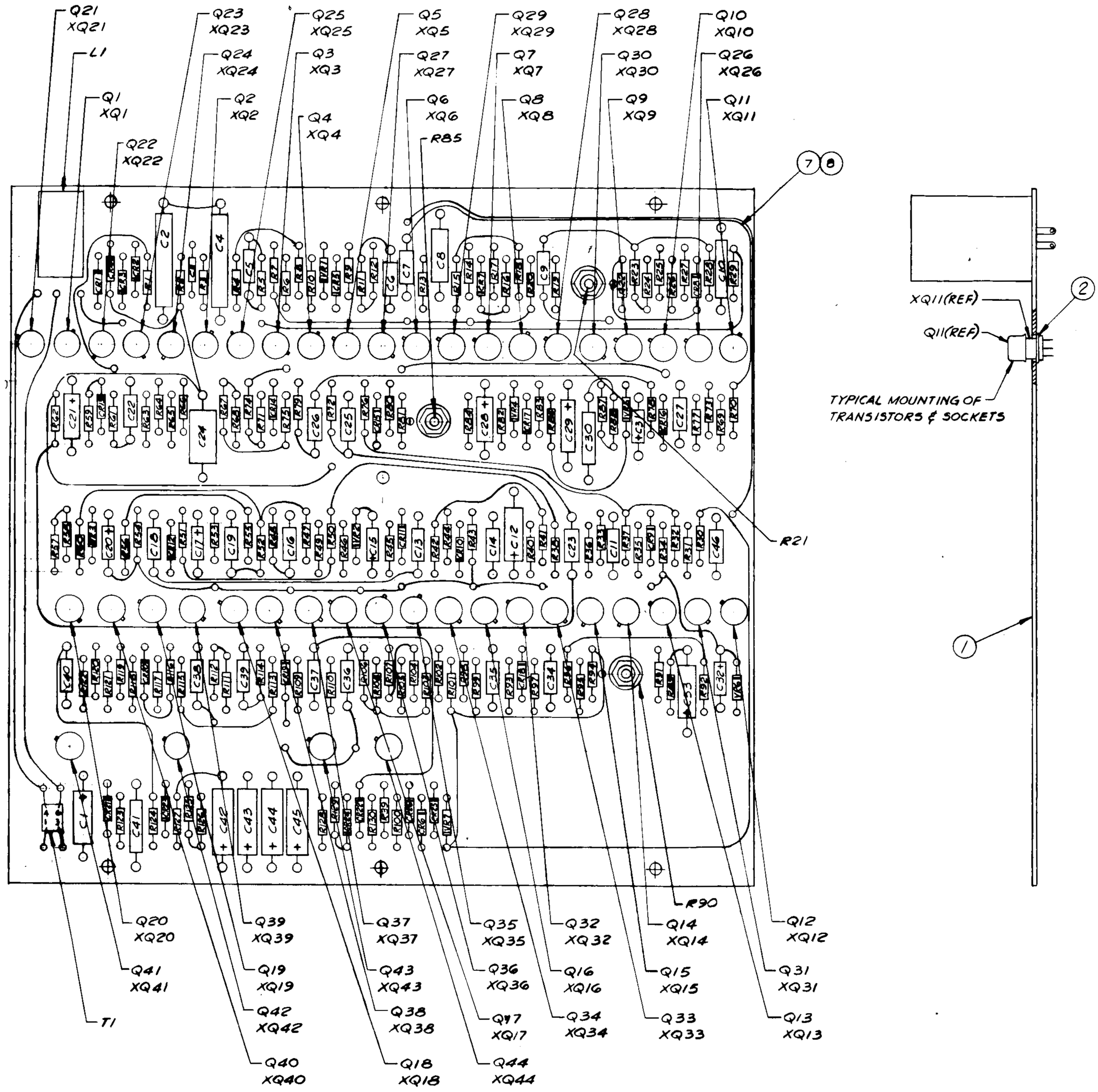


Figure 52. Power Supply Assembly (A1)
RCA Dwg 1843492 Rev C



WIRING SIDE

Figure 53. Component Board Assembly (A2)
RCA Dwg 1843905 Rev



COMPONENT SIDE

NOTES:-

1. BAR END OF CR'S & VR'S INDICATE CATHODE